MINING engineering

MARCH 1957

ELMER A. JONES
FIRST PRESIDENT
SOCIETY OF MINING ENGINEERS OF AIME

The AIME also publishes **Journal of Metals** and **Journal of Petroleum Technology**

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MINING engineering

VOL. 9 NO. 3 MARCH 1957

COVER

A brief biography of Elmer A. Jones, First President of the Society of Mining Engineers of AIME, appears on page 329. Cover by Herb McClure.

FEATURES

ARTICLES

TRANSACTIONS

PERSONNEL

THE following employment items are made available to AIME members on a nonprofit basis by the Engineering Societies Personnel Service, Inc. (Agency) operating in cooperation with the Four Founder Societies. Local offices of the Personnel Service are at 8 W. 40th St., **New York 18;** 100 Farnsworth Ave., **Detroit;** 57 Post St., **San Francisco;** 84 E. Randolph St., **Chicago 1.** Applicants should address all mail to the proper key numbers in care of the New York office and include 6c in stamps for forwarding and returning application. The applicant agrees, if placed in a position by means of the Service, to pay the placement fee listed by the Service. AIME members may secure a weekly bulletin of positions available for $3.50 a quarter, $12 a year.

MEN AVAILABLE

Geologist or Superintendent, B.A. in geology, 31. Five years experience surface and underground mining, exploration, and development. Experience includes mine geologist at large underground iron mine, exploration party chief, assistant manager small manganese open pit mine. Prefer South, East, or Midwest. M-306.

Geologist, experience includes seismic surveys, drilling, surveying, and one year with major gas transmission company. Veteran, 25, married. Willing to relocate in U. S. or abroad. Desire responsible position with opportunity for advancement. M-307.

Geologist, evening student with B.S. in geology, City College, 27, married, veteran. Desires position in field of geology. One year diverse engineering experience. Free to travel when school has been completed. Presently must locate in New York area. M-308.

Mine Manager, graduate mining engineer; 20 years experience in varied mine operation and development. Experience includes trackless mining on large scale. Broad knowledge of labor negotiation, plant construction, and cost control. M-309.

POSITIONS OPEN

Exploration Geologists or Mining Geologists, 25 to 45, from no experience to assistant project manager. a) *Assistant Project Manager,* with 8 to 15 years experience, to organize, plan, and direct a major exploration project. b) *Project Engineer or Geologist,* with 7 to 15 years practical experience in exploration. c) *Senior Engineer, Exploration,* with 5 to 12 years experience in exploration and development. d) *Engineering Exploration,* with two to three years experience in survey, geological, and/or topo maps, tonnage, and grade estimates. e) *Office Manager, Exploration,* to be responsible for accounting, purchasing, and related functions. g) *Chief Chemist,* with five to seven years experience, to construct, establish, and supervise the operation of an analytical laboratory of bauxite samples in the field. Salaries, $7,500 to $15,000 a year. Should speak Spanish or Portuguese. Locations, South and Central America. F4578.

Exploration Geologist, required by well established company in United States for exploration program in Liberia. Alluvia and foreign experience desirable. Salary, open depending upon experience. F4567.

Chief Mining Engineer, engineering graduate, with at least five years supervisory experience covering open pit operations for iron ore project. Salary, $7200 a year, plus car and bonus. Location, South. W4561.

Geologists. a) *Geologist,* young, with field experience in uranium or petroleum. Salary, $6000 to $8000 a year. b) *Senior Geologist,* with at least five years exploration and development experience in uranium, gas, or oil. Salary, $10,000 to $12,000 a year. Location, New Mexico. W4549.

Engineers. a) *Exploration Geologist,* young, with at least two years foreign experience in metal fields covering diamond drilling, trenching, geochemical, and geophysical prospecting. b) *Mining Engineer,* young, with production experience in underground gold or Au-Cu property. Salaries, $7200 to $8400 a year plus extras. Location, Philippines. F4529.

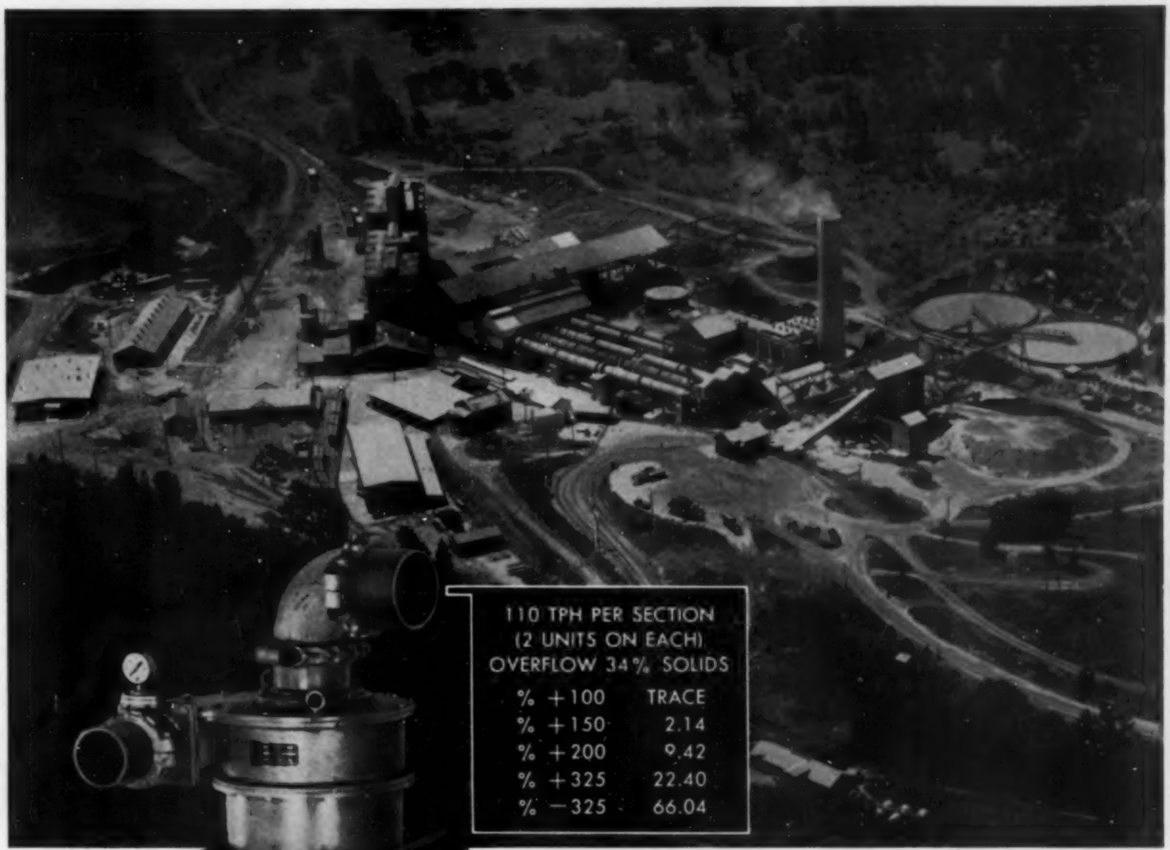
Mining Engineer, young, for underground and surface work at gypsum property. Salary, $5000 to $6000 a year. Location, New York State. W4488.

Exploration Geologist, about 35, with at least five years supervisory experience in metal fields. Single status preferred; will consider man with wife only. Salary, $10,000 to $12,000 a year. Location, Caribbean area. F4476.

Mine Tunnel Boss, with underground experience including the driving of drainage tunnels. Salary, $3900 a year plus bonus, room, and board for single man; $4800 a year, plus bonus, house, and utilities for married man. Location, Central America. F4475.

Ore Dressing Metallurgist, to work on process development and control in a progressive mining operation. Liberal housing and employe benefits. Salary, commensurate with experience. Location, East. W4493(a).

Metallurgist, with about ten years experience in the field of ore dressing. Experience in the nonmetallic flotation field, and in particular phosphate rock, desired. Salary, open. Location, South. W4492.



closed-circuit classification to 88% −200 mesh at 34% solids with Krebs Cyclones

Calaveras Cement Company, the largest mine ever to operate in California's historic Mother Lode, makes another major contribution to milling technology. In 1956, capacity per section at Calaveras was stepped up from 80 to 110 tons per hour. This called for better classification. Krebs Cyclones, model D20B, especially fitted to meet the objectives were installed. Tramp sizes in the final product are only a trace on 100 mesh even with high density at 34% solids compared to a previously fluctuating 11 to 16% solids. Only 26% as much water is required. Kwh per ton for classification and pumping to the thickeners has dropped 38%. Pressure requirement at cyclone inlet is 11 psi. Krebs Cyclone operation is simple; grind-out time on shutdown is eliminated. Maintenance after a year has been negligible.

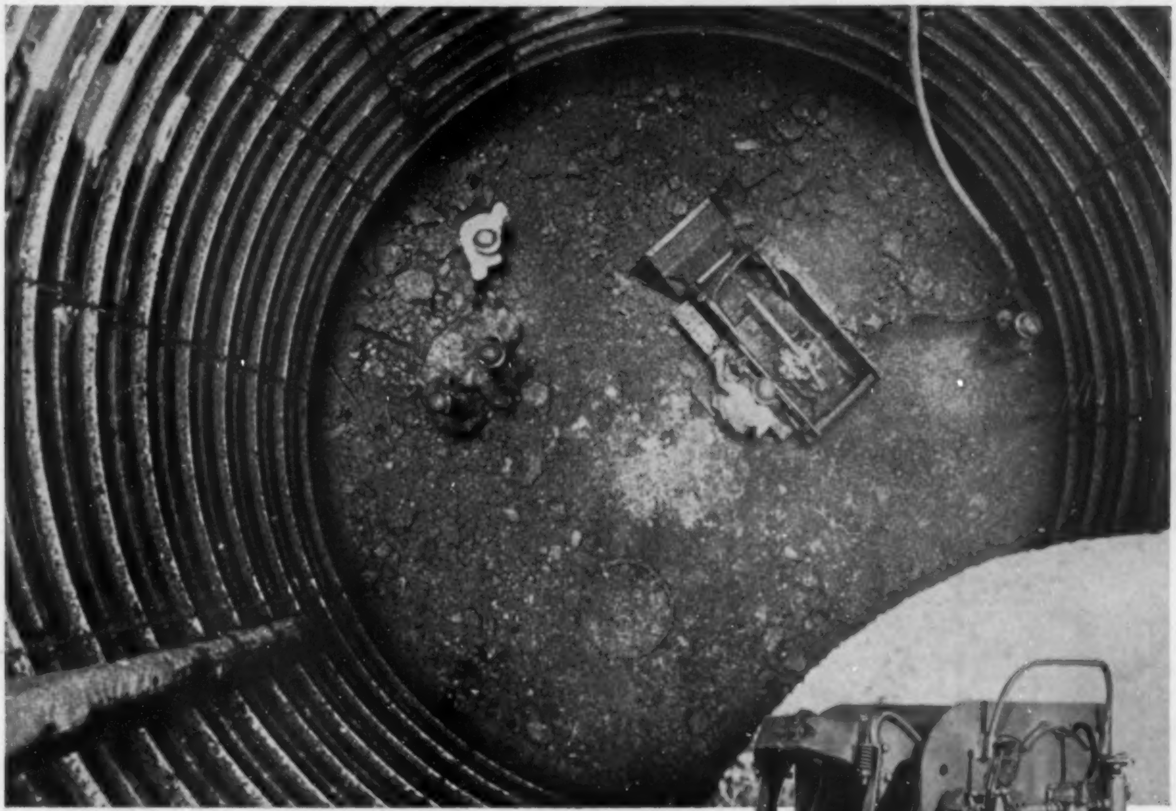
EE PRODUCTS

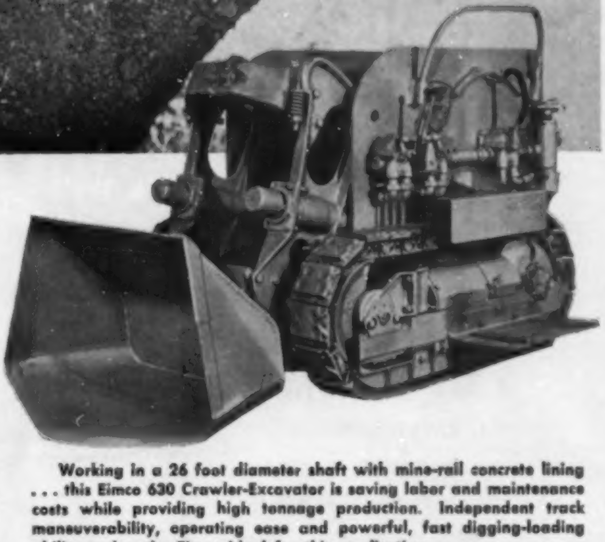
EQUIPMENT ENGINEERS INC.

41 SUTTER STREET SAN FRANCISCO 4, CALIFORNIA

Manufacturers of Krebs Cyclones, Valves and Clarkson Feeders

RUGGED BUTYL INSULATION plus neoprene jacketing gives this ANACONDA Mine Power Cable long life under rugged conditions: 60-ft. drop over rocky cliff, unprotected from sun or weather in northern open-pit mine.





MINERS USE EIMCOS WHERE PROFIT DEPENDS ON HIGH PRODUCTION

At exploration projects . . . and mucking low-grade ore where profit is realized only when high tonnage quotas are met — the Eimco 630 Crawler-Excavator is expanding production opportunities.

Increased demand for the versatile 630 by firms who previously were stymied in exploration and development projects because of tonnage requirements . . . is proof that Eimcos are helping to solve this production problem.

The 630 also is helping to recover large, low-grade ore bodies through exploration of deeper horizons. Areas that other underground development hasn't touched during years of continuous mining activity, are now worked profitably.

One important phase of these expansions is tough shaft sinking jobs. Often, occurrence of water adds to the already severe service conditions under which equipment must perform.

But as one superintendent put it, "We haven't had trouble digging the last feet of any wet shaft round with the Eimco and it really takes punishment."

Working in a 26 foot diameter shaft with mine-rail concrete lining . . . this Eimco 630 Crawler-Excavator is saving labor and maintenance costs while providing high tonnage production. Independent track maneuverability, operating ease and powerful, fast digging-loading ability makes the Eimco ideal for this application.

This is possible because the 6,000 lb. digging effort at the bucket lip gives the 630 tremendous crowding and digging power . . . enough to fill the big, half-yard bucket in any muck pile. And rugged construction with all vital parts protected against moisture and foreign material — insures long, on-the-job service.

In any underground excavating job . . . the standard Eimco 630 will permit you to increase your earning potential without addition of specialized machinery. Write today for full information!

THE EIMCO CORPORATION

Salt Lake City, Utah—U.S.A. • Export Offices: Eimco Bldg., 52 South St., New York City

New York, N. Y. Chicago, Ill. San Francisco, Calif. El Paso, Tex. Birmingham, Ala. Duluth, Minn. Kellogg, Ida. Pittsburgh, Pa. Seattle, Wash. Cleveland, Ohio Houston, Tex. London, England Gateshead, England Paris, France Milan, Italy Johannesburg, South Africa

BOOKS

ORDER THE FOLLOWING BOOKS THROUGH AIME— Address Irene K. Sharp, Book Dept. Ten percent discount given whenever possible.

World's Non-Ferrous Smelters and Refineries, ed. by H. G. Cordero, *Quin Press Ltd.*, 423 pp., $5.70, 1954. —This is the completely revised edition of a reference guide to the nonferrous smelting and refining plants of 55 countries. Approximately 650 companies are listed alphabetically within national and continental subdivisions, with special sections devoted to Russian undertakings and projected plants.

Surveying, by A. R. Legault, H. M. McMaster, and R. R. Marlette, *Prentice-Hall Inc.*, 417 pp., $6.75, 1956.—Subtitled *An Introduction to Engineering Measurements*, this book presents the development, theory, and application of all the essential surveying techniques.

Coal-Mining, by I. C. F. Statham, *Philosophical Library Inc.*, 557 pp., $15.00, 1956.—This is a general description of the scope and significance of the coal mining industry in Britain, past and present, aimed particularly at the layman and the mining novice.

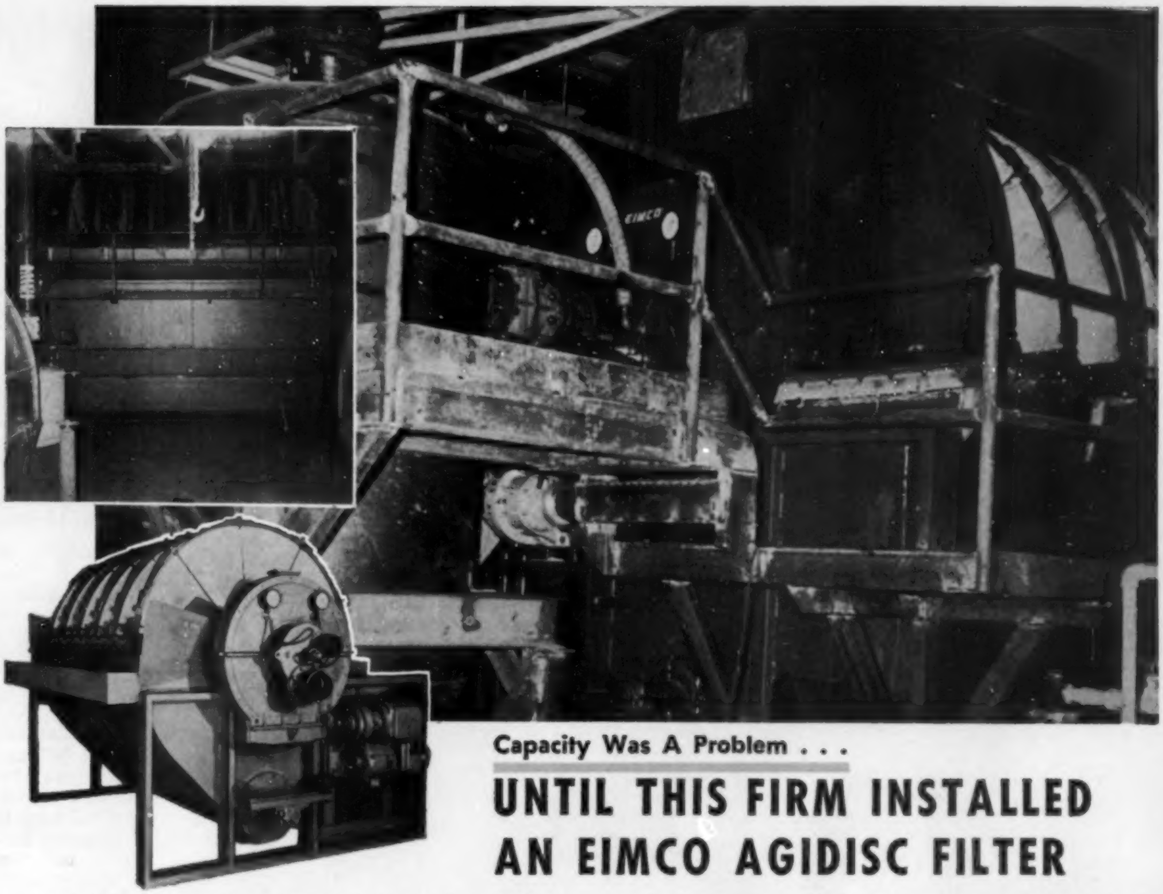
Petrographical Modal Analysis, by Felix Chayes, *John Wiley & Sons Inc.*, 109 pp., $5.50, 1956.—This is an elementary statistical appraisal intended to provide the student of petrology with the basis and techniques for determining the quantitative modal composition of rocks.

Industrial Engineering Handbook, ed. by H. B. Maynard, *McGraw-Hill Book Co. Inc.*, 1504 pp., $17.50, 1956.—This is an illustrated reference and guide for the practicing engineer and business manager on the principles, data, methods, and procedures of the whole field of industrial engineering.

Please Order These Publications from the Publishers

Timber Design and Construction Handbook, prepared by Timber Engineering Co., *F. W. Dodge Corp.*, 119 W. 40th St., N.Y.C., 622 pp., $12.75, 1956.—This is a comprehensive design reference and field handbook containing information on wood structures and research by timber scientists. It is arranged in sections on basic properties, design, and design standards.

(Continued on page 377)



Capacity Was A Problem . . .

UNTIL THIS FIRM INSTALLED AN EIMCO AGIDISC FILTER

Installation of an Eimco Agidisc Filter was made by a large nickel producing firm after a competitive-make of disc-type filter could not handle a nickel ammonia leach residue at the required production level.

Replacement of the 8′ 6″ × 10 disc filter with an 8′ 10″ × 10 disc Eimco Agidisc resulted in these production efficiencies:

ORDINARY DISC-TYPE		EIMCO AGIDISC
940 sq. ft. of filter area in 10 discs. It was necessary to by-pass one-fourth of tonnage past the filter to maintain required production level. Processed 17 tons of concentrate per day (75% of tonnage required for profitable operation).	**PRODUCTION COMPARISON**	1040 sq. ft. of filter area in 10 discs. Efficiently handles the tonnage that formerly was by-passed. Processes 24 tons of concentrate per day. With an increase of **25%** in filter area, the Eimco has boosted capacity by **40%.**
75% production efficiency was achieved only through considerable manual assistance. Excessive down time for filter tank cleaning.	**OPERATING EFFICIENCY**	In achieving 100% production efficiency, Eimco uses efforts of one man part time. Maintenance and labor costs are much less.
Poor cake discharge required manual assistance. Uneven cake formation. Severe classification rings on outer periphery of disc with thin, slimy cake near center.	**PRODUCT EXCELLENCE**	Efficient cake discharge without manual assistance. Ability of Agidisc to maintain uniform particle suspension has resulted in even, dry cake formations.

Outstanding success of the Eimco Agidisc Filter prompted this firm to convert five other disc filters into Agidiscs. They are convinced these installations are securing a ton of concentrate at the lowest cost per dollar of investment and maintenance.

Increasing the efficiency of your plant means greater returns. The Eimco Research and Development Center is staffed and equipped to help you solve your filtration problem whatever it may be. They'll be happy to assist you!

THE EIMCO CORPORATION

SALT LAKE CITY, UTAH

Research and Development Division, Palatine, Illinois • Process Engineers Inc. Division, San Mateo, California

Export Offices: Eimco Building, 51-52 South Street, New York 5, N. Y.

BRANCHES AND DEALERS IN PRINCIPAL CITIES THROUGHOUT THE WORLD

B-341


ALLIS-CHALMERS

Longyear

Bringing up core . . . with drill rods *in the hole*

Longyear Wire Line equipment allows more drilling time per shift . . . improves core recovery!

Another core sample heading for the box and the crew about to go for more *without pulling up the drill string.* That's drilling with Longyear Wire Line equipment!

Drillers using the Longyear Wire Line Core Barrel lower an "overshot" through the drill string to bring up the Inner Tube containing core. Here's what this can mean to *your* operation:

1 The drill string normally remains in the hole except when it is necessary to replace the bit. This eliminates much of the hard labor of drilling and allows more actual drilling time per shift.

2 Caving, the major cause of blocking and bit damage, is minimized. There is little chance for caving while the drill string is in the hole—which is most of the time.

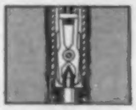
3 Longyear Wire Line Core Barrels are equipped with the water shut-off valve. In closed circuit drilling (possible with Longyear transmission pumps), the shut-off valve gives an immediate, positive indication of a block in the core barrel, eliminating costly "hunches" on the part of the drill runner.

Wire Line experience includes hundreds of thousands of feet drilled in many kinds of formations. Reports consistently show lower costs per foot of core recovered. In one overseas operation, switching from conventional NX equipment to BX Wire Line increased footage from ten to forty-seven feet per shift. In most cases when drilling in ground that is difficult to core, Wire Line improves core recovery substantially.

Looking ahead to your next drilling project, keep in mind that Longyear offers a complete line of Core Barrels and expert technical assistance in the selection of the right equipment for the formation you want to drill.

At end of core run, overshot assembly is lowered by wire through drill string.

At bottom drill string, overshot latches on to spear of inner tube.



Core-bearing inner tube reaches the surface, is freed from overshot.

Core is removed. Meanwhile, stand-by inner tube is dropped into the hole so drilling can be resumed as soon as it is in position.

Longyear

E. J. LONGYEAR CO. CABLE LONGCO

General Offices: Foshay Tower • Mpls. 2, Minn.

CANADIAN LONGYEAR LTD., NORTH BAY, ONT.
LONGYEAR ET CIE., PARIS, FRANCE

Diamond Core Drill Manufacturers • Core Drilling Contractors • Mining Engineering and Geological Consultants

THE WORLD IS OUR WORKSHOP

IN CALIFORNIA . . . AND THE WORLD OVER

Bucyrus-Erie Electric Shovels Cut Costs where they start . . . in the pit

A Bucyrus-Erie 6-cu. yd. 150-B is shown here removing overburden in a California open pit iron mine.

Big-output capacity plus month-after-month dependability are advantages that enable Bucyrus-Erie electric shovels to help hold down costs. In busy iron mines everywhere, these machines are helping owners cut costs with such outstanding advantages as:

1. Modern front-end design that combines light weight with great strength.
2. Sturdy construction, from boom point to treads, that saves maintenance and adds to life.
3. Ward Leonard variable-voltage control which permits rapid acceleration and deceleration and assures plenty of extra torque and power when it's needed.

Follow the lead of successful owners the world over — put a Bucyrus-Erie electric shovel to work keeping output high and costs low. You can choose from three models — the 4½-yd. 110-B, the 6-yd. 150-B, and the 8-yd. 190-B.

83L56C

BUCYRUS-ERIE COMPANY SOUTH MILWAUKEE, WISCONSIN

KENNEDY GEARLESS

PRIMARY AND

KENNEDY PRODUCTS

- Gyratory Crushers
- Swing Jaw Crushers
- Tube Mills
- Ball & Rod Mills
- Vibrating Screens
- Rock Feeders
- Air Swept Tube Mills
- Rotary Kilns
- Coolers, Dryers
- Preheaters, Deheaters
- Belts, Conveyors
- Pneumatic Transport Systems
- Waste Heat Boilers
- Pulverized Coal Firing Systems
- Steam Generators
- Asbestos Plants
- Complete Lime Plants
- Complete Cement Plants
- Complete Aggregate Processing Plants

#42 KVS Primary Gearless Gyratory Crusher with cast steel frame.

Kennedy cataract type AAA vibrating screens. Available in single, double, triple deck models. Heavy Duty Two-Bearing design simplifies installation and reduces maintenance.

Send for bulletins describing KVS world-famous Machinery and Equipment.

KENNEDY-VAN SAUN

Precipitator Automation

An electronic development by *Research-Cottrell Inc.* brings complete automation to the power supplies of electrostatic or electrically powered dust precipitation equipment, eliminating manual and visual electrical controls entirely. The control system continuously monitors and readjusts spark rate to maintain optimum voltage and power input for changing precipitator conditions. **Circle No. 1.**

Shock-Absorbing Drill Handle

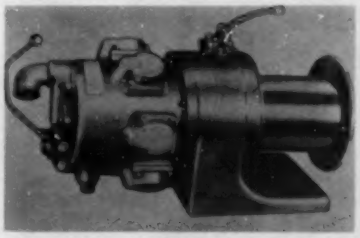
New standard equipment for Le Roi-Cleveland H-10, H-12, and H-111 sinker drills is a shock-absorbing handle which increases output by reducing operator fatigue. Vibration is absorbed by rubber cushions, and their dampening action is adjustable. Also available from *Le Roi Div.* of Westinghouse Air Brake Co. are modification kits for former models of these drills. **Circle No. 2.**

Portadrill

Winter-Weiss Co. has a heavy duty rotary drill which mounts on a Caterpillar D6 for vertical blast holing. Up to 27,000 lb can be applied on the bit and the drill averages a foot or more a minute of 9-in. hole in most formations. Two rotary compressors operating singly or together provide a maximum air pressure of 85 psi. Drill is also available truck or trailer-mounted. **Circle No. 3.**

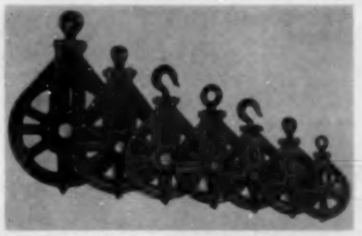
Air-Powered Hoist

Atlas Copco AB has introduced a new series of air-powered portable winch-type hoists designed for dragging, skidding, and lifting in mines and quarries. The 265-lb MHG-41 (shown) can handle loads up to 1100 lb, operates at 85 psi, and is equipped with 400 ft of 5/16-in. rope. New unit operates from creep to rope speeds ranging up to 160 fpm at full load. **Circle No. 4.**



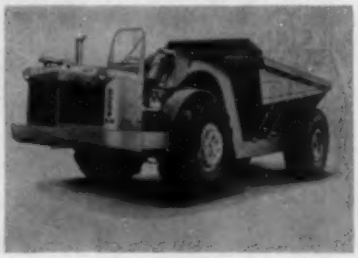
Blocks & Sheaves

Durolite blocks from *Sauerman Bros. Inc.* feature end thrust bearings to prevent side frame wear, free-moving swivels for easy positioning, and a cast bead on side frames to prevent fouling. Sizes stocked are 6 to 18 in. with bronze bearings and 8 to 42 in. with roller bearings. Sheaves are separately available in sizes from 6 to 18 in. (alloy steel) and 20 to 24 in. (cast steel). **Circle No. 5.**



Rear Dump Hauler

Euclid Div., General Motors Corp. offers the Model S-18, a rear dump off-the-highway hauler with a rated payload of 35 tons. Single axle tractor is powered by a 300-hp engine with Roots blower. Semi-trailer body is interchangeable with the bowl of the S-18 scraper. **Circle No. 6.**



Tractor Odometer

More accurate job data by recording distances traveled by tractors is possible with a new odometer, announces *Caterpillar Tractor Co.* Easily mounted on either spoke or disk-type idlers, the unit (shown with cover plate removed) gives 98 pct accuracy in the lower three gear ranges. It is inoperative in fifth gear. **Circle No. 7.**

Four-In-One Payloader

Previously available only on International-Harvester crawler models, the Drott *four-in-one* buckets are now offered as optional equipment on all *Frank G. Hough Co.* 4-wheel drive Payloaders. The attachment can be used as a shovel, clamshell, scraper, or bulldozer and may be mounted on models HH, HO, and HU. **Circle No. 8.**

News & Notes

Dorr-Oliver Inc. has announced plans for major expansion and reallocation of its U. S. production facilities and further expansion of Dorr-Oliver-Long Ltd.'s plant at Orillia, Ont. All domestic filter manufacture will be centralized at the Hazleton, Pa. plant . . . New industrial engine plant of *Caterpillar Tractor Co.* will be constructed on an 1100-acre site near Peoria, Ill.

Molybdenum...

AND SYMONS® CONE CRUSHERS

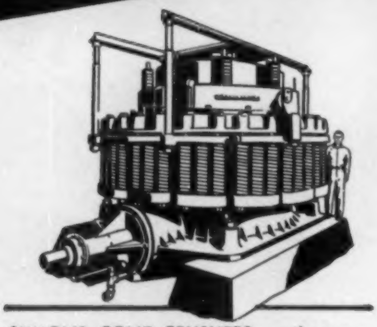
This view, showing a specimen of an etched cross section of a molybdenum ingot, was furnished by Climax Molybdenum Co., who now use a 60" Symons Primary Crusher, 12 Symons Cone Crushers, and 25 Symons Vibrating Rod Deck Screens.

• MOLYBDENUM, from the Greek "*molybdos*", meaning lead, is popularly referred to as "moly", and has its main commercial source in the mineral molybdenite. Increasing production of molybdenum has been essential for the manufacture of alloy steels used extensively in aircraft, automotive, heavy machinery, and many other industries.

Largest producer of "moly" in the world is Climax Molybdenum Company, supplying well over half of the free world production. Located high in the Rockies in Colorado, this miracle mine of modern times is presently the largest underground mining operation in North America. At Climax, a battery of twelve 7-ft. Symons Cone Crushers handle the reduction crushing of the vast tonnages of hard crystalline rock bearing the molybdenite ore.

For in molybdenum production . . . *as in all the great ore and industrial mineral operations the world over* . . . Symons Cone Crushers are the outstanding choice of leading producers for processing great quantities of finely crushed product at low cost.

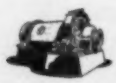
Nordberg Mfg. Co., Milwaukee, Wisconsin



SYMONS CONE CRUSHERS . . . the machines that revolutionized crushing practice . . . are built in Standard, Short Head, and Intermediate types, with crushing heads from 22 inches to 7 feet in diameter — in capacities from 6 to 900 tons per hour.

SYMONS . . . A REGISTERED NORDBERG TRADEMARK KNOWN THROUGHOUT THE WORLD.

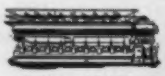
Symons Gyratory Crushers



Grinding Mills

Mine Hoists

Symons Vibrating Grizzlies and Screens



Nordberg Engines 10 to over 12,000 H.P.

C356

NORDBERG

MACHINERY FOR PROCESSING ORES and INDUSTRIAL MINERALS

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TORONTO • MEXICO, D.F. • LONDON • JOHANNESBURG

(21) WIRE ROPE CARE: An 80-page pocket-size manual, "Here's How to Keep Your Wire Rope Working," is offered by *American Chain & Cable Co. Inc.* Regarding wire rope as a precision tool, the booklet covers the basic steps in use and care and notes abrasion, lubrication, inspection, alignment of sheaves, winding on drums, bending fatigue, splicing. Recommendations point the way to get more for your wire rope dollar.

(22) JAW CRUSHER: Folder BU132-561 from *Universal Engineering Corp.* details features of the 4448 WRB eccentric jaw crusher. A 130,-000-lb unit, the crusher has a maximum capacity of 950 tph.

(23) BELT CLEATS: Slipping of gravel or other like material on an inclined conveyor belt can be stopped through the use of cleats such as those offered by *Flexible Steel Lacing Co.* Easily affixed in any pattern needed, the cleats are available in four heights: 7/16, ¾, 1, and 1½ in. All are 36 in. long.

(24) TEMPERATURE CONVERSION CHART: *Moeller Instrument Co.* offers a handy pocket-size temperature conversion chart. The easy-to-read tables of Fahrenheit and Centigrade temperature equivalents are a time saver. For easy reference, the 8½x3½-in. chart may be placed under a glass desk top.

(25) WORM REDUCERS: Specifications of the English-made Radicon worm reducers are described in a new brochure, D5604, from *David Brown Corp.* Dimensions and input hp ratings are given for types RHU, RHO, and RHV.

(26) INDUSTRIAL LOCOMOTIVES: Sixteen pages describe *General Electric's* complete line of industrial locomotives in new booklet GEA-6445. Entitled "Six Questions to Ask When Buying an Industrial Locomotive," the guide points out answers to the problems that a prospective buyer might meet.

Free Literature

(27) HOISTS: *Yale & Towne Mfg. Co.* has a catalog covering roller chain and link chain Pul-Lifts. The lightweight ratchet hoists are produced in capacities of ¾ ton to 15 tons.

(28) EARTHMOVING: Three new bulletins are available from the Construction Machinery Div. of *Allis-Chalmers Mfg. Co.* Highlights of the HD-11G and HD-6G diesel powered

crawler tractor shovels are noted in folders MS-1137 and MS-1126. The third pamphlet, MS-1149, details features of the four Allis-Chalmers pull-type scrapers.

(29) OSCILLATING CONVEYOR: Coilmount is the latest addition to the *Link-Belt* line of oscillating conveyors for bulk materials handling. Motion is imparted to material carried in a trough by means of a constant-stroke eccentric drive that produces an upward and forward oscillating movement. Since there is no return run, carryover is eliminated, and oscillation levels out surge loads. Sections can be assembled in lengths up to 100 ft. Booklet 2644 is a guide to correct selection and application of stock size Coilmount units.

(30) ROTARY STOPER: Leaflet E 909 from *Atlas Copco* points up the design features of the Falcon autofeed rotary stoper for overhead drilling. Overall length is reduced by elimination of the anvil block, and air formerly consumed in the block is used to increase piston impact. The stoper is provided with feeds facilitating 24 and 30-in. steel changes. A push button-actuated bleeder valve releases pressure to collapse the extension feed.

(31) SPIRALOK DYNAMITE ASSEMBLY: The Explosives Dept. of *Hercules Powder Co.* has a bulletin covering the use of the Spiralok joint feature in making continuous powder columns. Advantages include easy assembly and disassembly, rigid coupling, and maximum protection for the charge. Time is saved and results are better, it is claimed, when Spiralok charges are used in seismic exploration and in submarine and dredging work. Included in Form 200-71 is a description of the XC-47 primer, recommended for severe shot-hole conditions.

(32) NEOPRENE-SHEATHED CABLE: *National Electric Products Corp.* has a new catalog-bulletin which discusses composition, in-use properties, and suggested applications of type RR rubber insulated, neoprene sheathed cables. Forty pages of reference material and illustrations are provided, and charts give data on size, strand construction, insulation sheathing, diameters, and shipping weights.

(33) MINING IN MONTANA: *Montana Bureau of Mines and Geology* at Montana School of Mines has released information circular No. 14 which lists known Montana mining enterprises in 1956. Ventures covered include those which are active and producing, developing or exploring, or idle but not abandoned. Minerals concerned are also included.

MAIL THIS CARD

for more information on items described in Manufacturers News and for bulletins and catalogs listed in the Free Literature section.

3

Mining Engineering **29 West 39th St.** **New York 18, N. Y.**

Not good after June 15, 1957—if mailed in U. S. or Canada

Please send { More Information ☐ / Price Data ☐ / Free Literature ☐ } on items circled.

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61	62	63	64						

Students should write direct to manufacturer.

(34) MINING AND QUARRYING STEELS: Drill steels from *Bethlehem Steel Co.* are detailed in 20-page Booklet 345. Recommendations for forging and heat-treatment are included with descriptions of standard and Ultra-Alloy hollow drill steels; solid and auger drill steels; and broaching, channeller, and stone-dressing steels.

(35) SWIVEL JOINTS: Use of swivel joints on air and hydraulic lines may increase their useful life by eliminating kinking and twisting. *Chiksan Co.* offers Catalog G-4 which covers ball-bearing swivel joints for all purposes. Replacement parts, lubricants, and packing units are also detailed.

(36) CYCLONES: Bulletin 121 from *Equipment Engineers Inc.* explains features of the Krebs cyclone classifiers. It also details results obtained with various models of the Krebs cyclones in working several physically varied slurries toward different objectives. Capacity of the 10-in. models is 200-300 gpm, and of the 20-in. models is 500-800 gpm.

(37) STEAM SOLENOID VALVE: A new packless, internally pilot operated, 2-way solenoid valve has been introduced by *Automatic Switch Co.* As described in Bulletin 8222A, the valve may be used in a variety of applications for the automatic control of the flow of steam, hot fluids, or gases at temperatures up to 400°F. Body and bonnet are of forged brass. Teflon disks assure tight shut-off when solenoid is de-energized.

(38) OFF-HIGHWAY TRUCKS: Photos and brief descriptions cover 11 models of *Dart Truck Co.* haulage vehicles in 4-page Bulletin 1056. Details are given on 10 to 55-ton end dumpers, a 50-ton bottom dump coal hauler, a 25-ton crane carrier, an 18-ton underground conveyor dump shuttle, and an oil field unit. Major construction features are noted in addition to specifications.

(39) PRODUCT LITERATURE: *Jeffrey Mfg. Co.* has a 48-page pocket-size booklet, No. 888, which elaborates on company products (mining, material handling, and processing equipment), and production facilities for mechanical, electrical, and hydraulic machines and components. Among the many items covered are: chains, transmission machinery, conveyors, feeders, electronic controls, magnetic separators, crushers, continuous mining machines, shuttle cars, drilling equipment, mine locomotives, mine ventilating fans.

(40) ROCK BOLTING: Information on the use of a grouted rock bolt is offered by *Sika Chemical Corp.* The Perfo system explained employs a perforated steel sleeve that is filled with mortar and placed in a drill hole. A reinforcing bar is thrust into the sleeve to force mortar out through the perforations and solidly fill all the space between the sleeve and surrounding rock. Advantages claimed to result are uniform anchorage, uniform stress, no corrosion, secondary blast resistance. Installation is simple—close drilling tolerances are not required. Two sizes of sleeves are available—1 1/16-in. ID and 1¼-in. ID.

(41) CLASSIFIER: *Sharples Corp.* has an air vortex classifier for dry powdered materials. Super Classifier is said to combine cutpoint sharpness and high efficiency with high capacity. Compact unit has a capacity from 250 lb per hr to 10 tph. Standard models can be manifolded for inert gas operation.

(42) ROD DECK SCREEN: Bulletin 94C from *Nordberg Mfg. Co.* has four pages of specifications and features of the Type K Symons Rod Deck screen. Spring steel rod surface is resistant to abrasion. Any rod or group of rods may be replaced without disturbing the remainder of the deck. Molded rubber mounting permits handling large material without screen damage.

(43) COMPRESSORS: Kellogg Div., *American Brake Shoe Co.* has a new 20-page catalog covering its line of 1/3 to 20 hp air compressors for automotive and industrial use. The illustrated booklet gives complete specifications on single and 2-stage models, portable models, tanks, pumps, and accessories. Useful charts and general data are included.

(44) HIGH TENSION SEPARATORS: A 4-page technical bulletin, HTB-103, on high tension separators is available from *Carpco Mfg. Inc.* Electrostatic separation is compared with high tension or electrodynamic separation. Minerals which can be separated by high tension units are listed. Included is a typical plant flowsheet.

(45) REPLACEABLE BLADE BITS: Blue Demon soft-medium-hard formation bits with replaceable blades for economical drilling are offered by *Herb J. Hawthorne Inc.* Catalog 656 includes data on the entire line and a six-part article called "Engineering a Hole in the Ground."

(46) CONCRETE DENSIFIER: *Sika Chemical Corp.* has a concrete densifier called Plastiment which controls set and reduces water content in cement without increasing air content. The result is uniformity, crack resistance, water-tightness, and surface hardness. Furnished in liquid or powder form, Plastiment may be stored indefinitely and may be used with all types of cements and aggregates.

(47) POWER SHOVEL: A new 1-yd shovel by *Bucyrus-Erie Co.* will speed stripping and loading operations. The 30-B is offered with a choice of any of five crawler mountings, or a rubber-tired carrier. The front end is easily convertible to shovel, dragshovel, crane, dragline, or clamshell.

(48) JIG: Wemco-Remer jigs for large tonnage low ratio concentration applications are available from *Western Machinery Co.* Uniform permeability of the entire bed mass is provided by a low frequency long stroke combined with a high frequency short stroke. Jigs are claimed to have greater capacity per unit of bed area and greater selectivity. Flowsheets are included in Bulletin J2-B3.

(49) TOURNATRACTOR: Form 54-005-T from *LeTourneau-Westinghouse Co.* gives details on features of the 206-hp rubber-tired Tournatractor. The 28-page booklet puts emphasis on speed, between-job mobility, emergency electric power, interchangeable equipment highlights of these large versatile units. Adaptable to most types of towed equipment, the tractor is shown in use with seven available attachments and a line of auxiliary tools.

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New York, N. Y.

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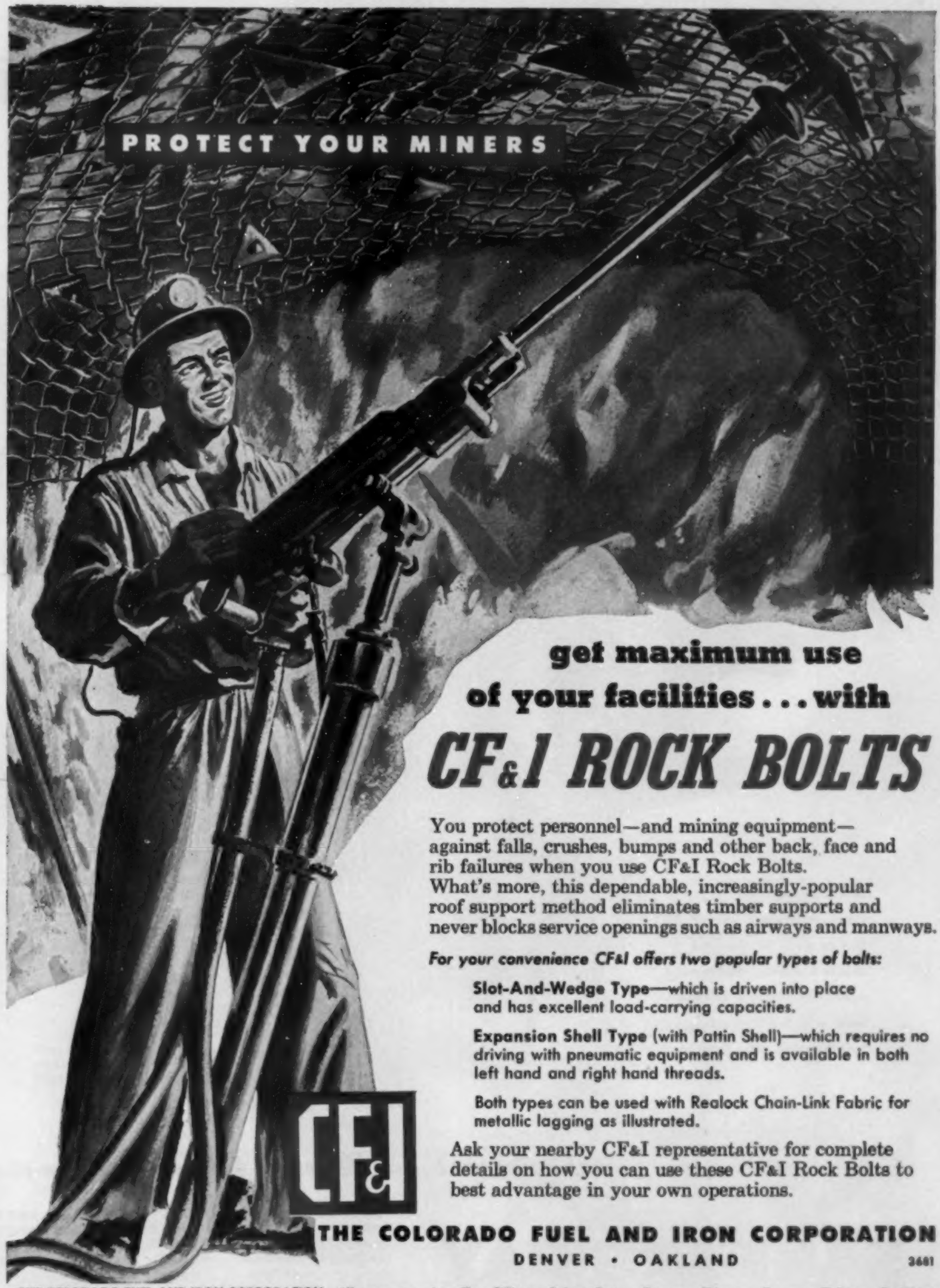
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Another New
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Development
by Sanford-Day

S-D Hydraulic for dumping

Although the need for simultaneous dumping of two or more Granby-type cars is a remote requirement, it is possible, as shown here, with S-D Hydraulic Self-Dumping Mine Cars.

Is there something special you need in mine cars? You will probably find the answer in our plant

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Knoxville, Tennessee

"SUPER MARKET FOR MINE CARS" — *all types* * PRECISION WHEELS * "BROWNIE" HOISTS, CAR RETARDERS, SPOTTERS, PUMPS AND OIL SPRAY SYSTEMS * GISMO SELF-LOADING TRANSPORT that loads *(mucks)* in development or production . . . transports . . . supports 2 to 5 jib mounted drills . . . back fills . . . moves boulder rocks . . . makes its own roadways and cleans up completely — a new method of hard rock mining offering a tremendous reduction in cost per ton!

Self-Dumping Car answers need any car in a trip anywhere!

No Fixed Dumping Point or Ramp Required!

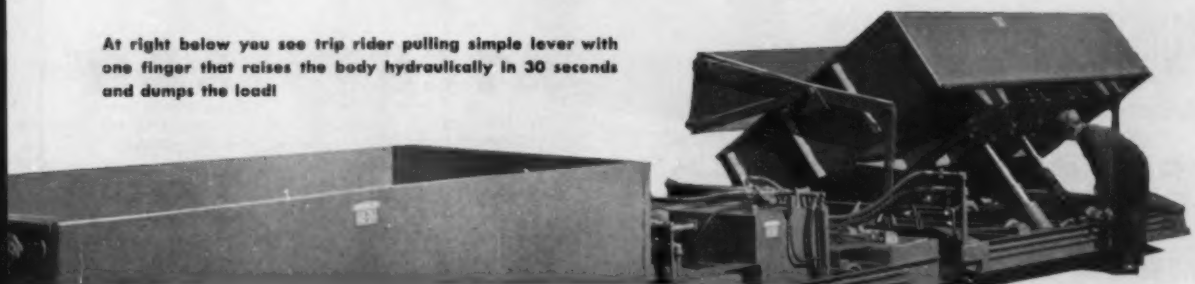
Twenty of these new cars were recently built for a large steel company to haul waste material out of mine development areas for disposal at outside ravines. The new S-D Hydraulic Self-Dumping Cars met the need for cars to operate in train and dump independently at any place. Of course, each car may be unloaded at the same fixed dumping point.

A pair of telescopic hydraulic cylinders raise the body to a dumping angle of 40 degrees. The trip rider selectively dumps each car by means of a lever located on side of underframe. Hydraulic power is supplied by a power unit mounted on a small car that is coupled in the trip. Hydraulic hoses connect the cars by means of quick-connect-and-disconnect self-sealing couplings. The car body raises or lowers in less than 30 seconds. Here is a car that could save you many man-hours and increase haulage efficiency if fixed dumping points are not practical or desirable. *It is another example how cost-conscious mining men turn to Sanford-Day for the engineering know-how to help them successfully solve haulage problems.*

Trip may be halted and each car dumped one-after-another, or, of course, trip moved on to each desired dumping point. Power unit car is normally located behind locomotive, although, as shown here, it may be coupled between cars.

Each S-D Hydraulic Self-Dumping car pictured here has a 10-ton rock capacity, and is approximately 17 feet long, 7 feet wide and less than 4 feet high from top of rail.

At right below you see trip rider pulling simple lever with one finger that raises the body hydraulically in 30 seconds and dumps the load!



MODERN HEAVY-DUTY CAT* FOR EVERY JOB

From a quarter century of diesel leadership, now comes the world's most advanced line of diesel engines.

Developed by Caterpillar research, these compact units pack more power in less space and deliver greater efficiency, greater economy and longer life in any application.

You have your choice of hundreds of variations in engines up to 650 HP (maximum output capacity), electric sets up to 350 KW (continuous duty) and marine engines up to 500 HP (continuous duty). They're available as original or replacement power for excavators, hoists, crushers, electric power, pumps, boats, loggers, sawmills and other equipment.

Why they do a better job than ever

These modern heavy-duty diesels feature the four-cycle design which provides a smooth, effective power stroke and a more efficient utilization of power. They require practically no attention. Their fuel system requires no adjusting. And Caterpillar's single-orifice fuel injection valves with the precombustion chambers permit the use of such low-cost fuels as No. 2 furnace oil without fouling. All these and other features add up to new standards of performance in diesel power.

A quarter century of diesel leadership

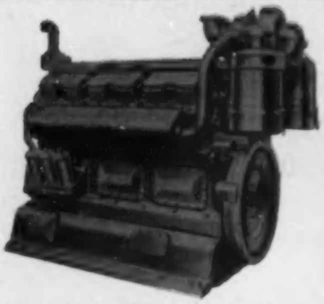
For modern power that stems from a quarter century of diesel leadership, specify Caterpillar units. Leading manufacturers can supply them in the equipment they build.

For complete information about them, see your Caterpillar Dealer. He backs you with prompt service. He has the experience and technical knowledge to help you with your power problems.

Caterpillar Tractor Co., Peoria, Illinois, U. S. A.

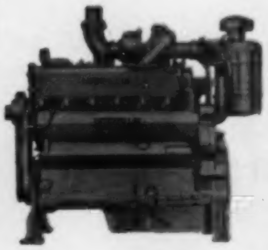
HUNDREDS OF DIFFERENT UNITS TO MEET YOUR POWER NEEDS

D397
with Turbocharger
650 HP†



Also available as a Roots blown, naturally aspirated or spark-ignition engine — and as an electric set, marine engine or torque converter power unit. Choice of air, electric or gasoline starting system.

D337
with Turbocharger
310 HP†



Also available as an electric set, marine engine or torque converter power unit. Choice of air, electric or gasoline starting system.

CATERPILLAR*

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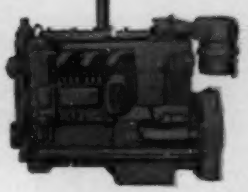
DIESELS



NEW D318 (Series G) Turbocharged

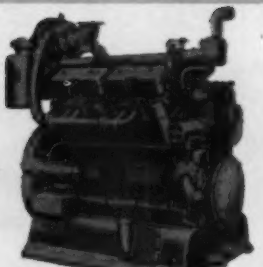
175 HP†

NEW D315 (Series G) Turbocharged

115 HP†

SMALLER, LIGHTER AND LOWER PRICED!

Keeping in line with Caterpillar's continued diesel leadership are these new Series G engines. They are designed for use in installations where space is at a premium. Both are small, light and low-priced; yet they deliver dependable power with the renowned Caterpillar durability. They are available naturally aspirated (above) or turbocharged. Choice of air or electric starting system.



D375 with Turbocharger

430 HP†

Also available as a Roots blown, naturally aspirated or spark-ignition engine — and as an electric set, marine engine or torque converter power unit. Choice of air, electric or gasoline starting system.

D342 Naturally Aspirated

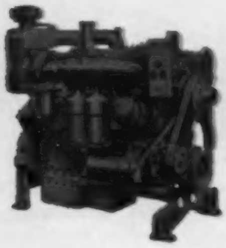
210 HP†

Also available as an electric set or marine engine. Choice of air, electric or gasoline starting system.

D339 Naturally Aspirated

140 HP†

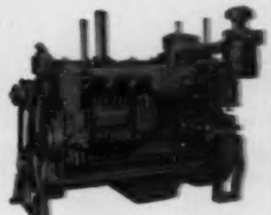
Choice of air, electric or gasoline starting system.



D326 Naturally Aspirated

200 HP†

Also available as an electric set, marine engine or torque converter power unit. Choice of air, electric or gasoline starting system.



D318 Naturally Aspirated

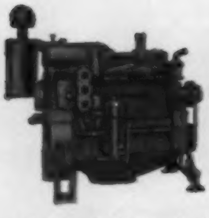
137 HP†

Also available as an electric set, marine engine or torque converter power unit. Choice of air, electric or gasoline starting system.

D315 Naturally Aspirated

91 HP†

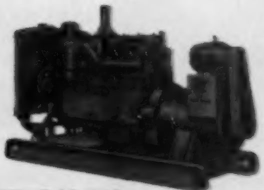
Also available as an electric set, marine engine or torque converter power unit. Choice of air, electric or gasoline starting system.



D311 Naturally Aspirated

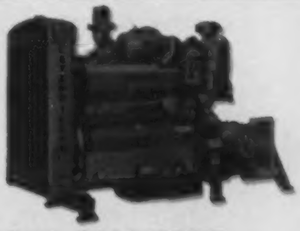
65 HP†

Also available as an electric set. Choice of air, electric or gasoline starting system.



ELECTRIC SETS

Dependable electric power, featuring the new Cat Generator, is available in standard voltages, 60-cycle, in the following KW sizes: 30, 40, 60, 100, 150, 165, 200, 225, 250, 315, 350. Also available as 50-cycle and DC units. The new generator brings you the best features of self-regulated and externally-regulated generators in one compact package.



TORQUE CONVERTER POWER UNITS

Many different arrangements are available for each of six Caterpillar Engines to provide you with a greater selection of power packages. You have a wide choice of power units and a wide choice of output shafts.

† maximum output capacity

Grant Large Manganese Concession

British South Africa Co. announces grant of a 2460-square mile manganese concession in Northern Rhodesia to Vanadium Corp. of America. Property, to be known as the Chilili East Manganese Area, is located near a 200-square mile concession purchased by Vanadium Corp. in late 1955. Work on the smaller area is claimed to have proved reserves sufficient for ten years at the company's current rate of consumption.

DMEA Uranium Prospecting Program Still Active

The Defense Minerals Exploration Administration, since its establishment in 1951 and up to the end of 1956, has received 669 applications for federal money to finance uranium exploration. Contracts amounting to a maximum of $4.62 million have partnered DMEA with 151 applicants in the search for more uranium ore. In 1956, 179 applications were received. Spokesmen expect that $50 million worth of material will be discovered for each million the government invests.

Biggest Year For Stainless Steel

Production of all types of stainless steel ingots reached 1,210,569 net tons during 1956, a new high according to the American Iron & Steel Institute. Reported production of low-nickel types showed a tenfold increase over 1955.

First Canadian Potash Refinery Projected

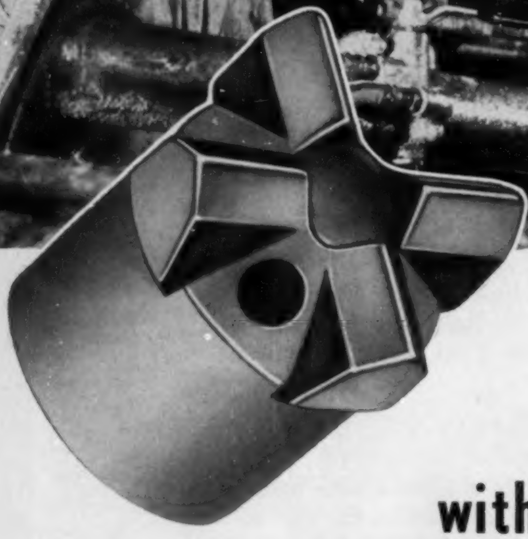
Potash Co. of America will begin construction of a $20 million potash refinery at Patience Lake, Saskatchewan in early summer. The refining operation will be a Canadian first. Production is expected to begin in November 1958. Capacity will be 4000-4500 tpd, or about 1.5 million tons annually. A mine shaft is being sunk at an estimated cost of more than $3 million to reach beds lying at a depth of about 3400 ft. Potash reserves of the province are estimated at 100 billion tons.

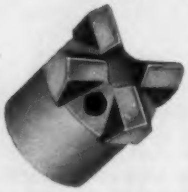
Copper—Production, World Stocks Up

World stocks of refined copper climbed 132,275 tons to a total of 353,601 tons in 1956, according to the Copper Institute. Production rose by nearly a quarter-million tons. Outlook this year, according to the Copper & Brass Research Assn., is to U. S. capacity of 1.19 million tons and a world output increase to 3.5 million tons.

Mercury Continues Upward Trend

Domestic mercury production in 1956 continued the climb of the last five years. New Idaho and Alaska mines pushed most of the 20 pct increase. Imports were also up, some 250 pct higher than those of 1955.





Plan Largest

High Tide . . . . . . Low Tide At Walton

Nova Scotia, the "New Scotland" that hangs precariously off the southern extremity of New Brunswick is an old land of eroded mountains, laced with lakes, and resplendent with rugged scenery.

One natural phenomenon of the province, which is as unique as it is impressive, is the Bay of Fundy and its strange tides.

Along this arm of water that separates most of Nova Scotia from the mainland and fingers into the land itself, tides have been measured up to 75 ft, the highest in the world. Towns which are miles from navigable waters in the morning become deepwater ports by noon.

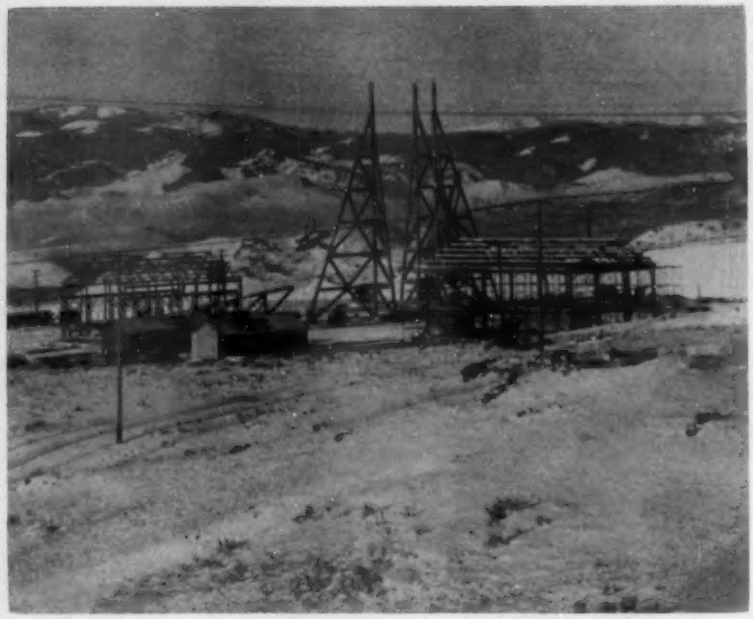
The tides have a particular interest for Magnet Cove Barium Corp.'s mining, milling, and shipping operation at Walton, N. S. where barite is processed for the oil industry. Vessels hauling barite from Walton Harbor must leave at exactly high tide, for once the water reaches its peak it immediately begins to drop. A trained eye must be kept on both loading progress and the height of the harbor water. Even the shortest delay could result in a ship remaining in port an extra day (which is very costly) or, even worse, running aground before it clears the harbor. The water at Walton rises to about 20 ft at high tide, refloating the ships from their special cement cribs for passage out to the Bay of Fundy.

Local stories have it that the barite deposit was found when a group of geologists were invited out to look at Walton's *red marble*. The 12-ft outcropping was enthusiastically explored and a huge deposit was discovered. The mining operation was basically a quarry operation for many years. But, with the completion of a 1000-ft shaft this year, the mine will go underground.

Cement cribs support loading vessels at low tide. An underground conveyor connects loading facilities with nearby mill.

ABOVE: Magnet Cove Barium Corp.'s pit at Walton has been excavated to a depth of some 300 ft. Small blasts loosen material for loading by power shovels into trucks that make a three-mile run to the mill. Structure at left is the headframe for the new 1000-ft shaft that will start an underground operation expected to begin this year. LEFT: Magcobar's mine engineer, superintendent, and geologist confer over a model of the large barite deposit.

Plan Largest Mine Hoist M-G Sets For Ryan Shaft



Southwest view of Ryan shaft site shows the three legs of temporary headframe now in place. Framework of building shown to right of headframe is to be the office and dry. Being erected to the left of the headframe is the east sinking hoist room.

The surface site of the Anaconda Co.'s Ryan shaft in Butte, Mont. is now being cleared, and sinking is expected to be under way early this year. Two mine hoists planned, to be completed in the fourth quarter of 1957, will include two 3000-hp 600 v d-c motors operating at 500 rpm and capable of working at 200 pct frequently-applied load and 225 pct occasionally-applied load.

The hoist will operate from four hoisting levels. The shallowest is to be at the 1636-ft level and the deepest at 4720 ft below the collar of the shaft. The 26,000-lb haulage skip will carry a pay load of 36,000 lb at a maximum speed of 2846 fpm. Total cycle time, including loading time of the skip, will be less than 2 min from the 4720-ft level. Speed will be controlled by a current-limiting system employing magnetic amplifiers.

The two 3000-hp motors on each hoist will be powered by a 5000 kw, 600 v, 514 rpm generator set. The two 2500 kw generators are to be driven by a 7000-hp 2300 v synchronous motor with 250 pct pullout torque. The synchronous motor is energized by a full voltage air break drawout type switchgear unit. Metal-clad switchgear for hoist house feeders and auxiliaries will complete the installation. Westinghouse Electric Corp. will supply the electrical equipment.

AEC Will Close Two Uranium Ore-Buying Stations

The uranium ore-buying station and sampling plant operated at Marysvale, Utah, since March 1950 will cease accepting ore at the close of business on March 15, 1957, according to the Grand Junction operations office of the Atomic Energy Commission. The station was established to speed development of the area by providing an ore market, but most of the regional mines are now selling their ore directly to Vitro Uranium Co. or to the AEC at Salt Lake City. Continued operation would mean an unnecessary step in the movement of ore.

Similarly, the station and sampling plant in operation near Globe, Ariz. since July 1955 will stop accepting ore on June 30, 1957. Ore tonnage received at the Globe station and reserves developed in the district have been much smaller than expected. Ore is low grade and refractory to present processes.

Control Emphasized At Sullivan Mine

Traffic control *brains* of the Sullivan Mine at Kimberly in southeastern British Columbia are contained in a complete two-way communications system at main level. Six electric locomotives working the 10-mile underground area are all equipped with Minephones by Mine Safety Appliances Co. The system is powered by the same 250 v d-c source used by the locomotives. Phone sets employ a frequency modulated carrier of 88 kc which does not interfere with the mine's conventional phone system. Equipment is mounted on each locomotive in a shock-resistant cradle in a dust-tight splash-proof metal case. The former system of control by block signals and standard phones has been eliminated.

Sullivan control room also has electronic devices to trace movements of mine locomotives.

DRIFTER, STOPER, SINKER—ALL IN ONE

Ease of operation is demonstrated in mining application. Note the accessibility of controls. The Thor 390 is mounted on the model 680 72" telescopic leg.

Optional feed travel legs available in two lengths for No. 390 drilling machine—36" model 68 leg and 48" model 67 leg.

Thor 390 one-man drilling machine

Here's the most versatile, productive drill in mining and quarrying—the Thor 390. This powerful drilling machine combines a drifter, sinker and stoper.

Get a Thor 390 on the job and you get a real profit building combination—one tool for three jobs, and what a performance combination—one man operation, reduced operator fatigue, plus faster drilling.

All controls are grouped on the backhead for safe, convenient operation. Thor's six-position throttle gives a complete range of control. Thor 390 is equipped with a line oiler—automatic water valve, replaceable with a plug for dry operation.

Call your Thor factory representative for a demonstration. Thor Power Tool Company, Prudential Plaza, Chicago 1, Illinois.

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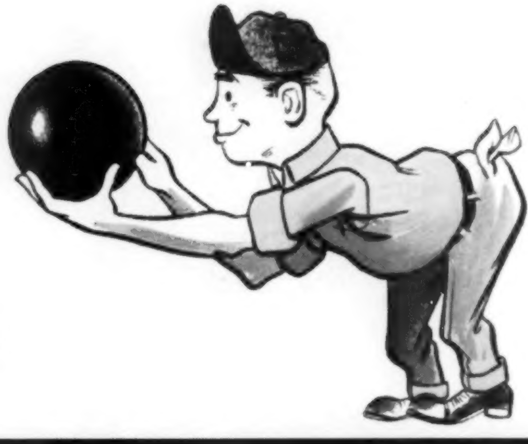
The Bowling Champ
buys a custom-made ball
because he gets
something **EXTRA**



the profit-wise operator

BUYS TRAYLOR REDUCTION CRUSHERS

for the same reason

Traylor Reduction Crushers are famous throughout the industry for the extra *production* and extra *profits* they put into mining operations. Traylor-made in ten sizes, with feed openings from 1½" to 22", Traylor Reduction Crushers provide capacities up to 590 tons per hour. For complete specifications write for Traylor Bulletin No. 11-120.

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TRAYLOR-MADE

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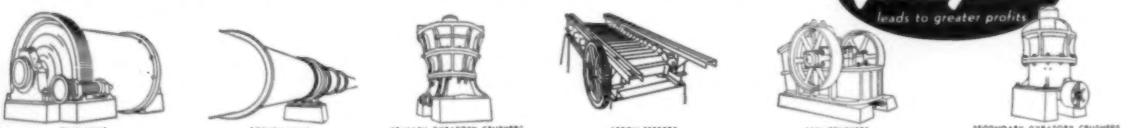
A Traylor leads to greater profits



BALL MILLS — ROTARY KILNS — PRIMARY GYRATORY CRUSHERS — APRON FEEDERS — JAW CRUSHERS — SECONDARY GYRATORY CRUSHERS

AIME and The Professional Engineer

MINING engineering

DRIFT

IN the many discussions which have occurred in the past few years in relation to the problems which face the engineering profession and in particular our own field of minerals engineering, we have, even in these columns, used the word *professionalism* very loosely, without attempting to define its implications.

It is felt that such a definition should be established, and that these implications as to the interrelationships which derive from it between AIME and its members, between the Societies and Divisions and their members, and between the members and AIME, the Societies, and Divisions, should be clarified.

As a basis for what is hoped will be discussions on the subject, the following is offered, bearing in mind that we speak not of a professional title or license to practice engineering, but of functional attributes of professionalism:

> "A Professional Minerals Engineer is one who has devoted his endeavors to the extraction of raw materials from the earth, to their processing and refining, and to their preparation for subsequent manufacturing or consumption. He applies to these processes a knowledge of mathematical and physical sciences acquired through study, practice and experience. He endeavors to abide by limitations imposed by economical factors, tempers his actions by judgment and the realization that his function is dedicated to the progress of civilization and the comfort, health, safety, and welfare of mankind."

The engineer is thus somewhere between the thinker (the scientist) and the doer (the technician). In most cases his endeavors do not bring him superabundant riches or power, but he obtains satisfaction in knowledge and in accomplishment. His activities are concentrated on the use of machines and on the processing of materials, his human relations are confined in most cases to using humans as operators of the machines, until he reaches managerial positions where human engineering becomes more important than engineering responsibilities as such.

AIME is basically an association of professional engineers and of their associates, joined together for the exchange of ideas leading to self-improvement, as well as for more sociable purposes, leading to better knowledge of one another and of each individual's problems. As a national entity it has certain functions and responsibilities which cannot and should not be delegated.

It is the spokesman for the profession; it should point out to management shortcomings in their relationship to their engineer employes, and suggest remedial steps. It should establish professional standards and obtain from the members not only minimum compliance with such standards but encourage that they be excelled. It should establish those meetings and conferences where the social phase of the association are fostered. AIME should consider itself in its relation to the profession in much the same light as the Bar Association is the professional society for lawyers, or the Medical Association for doctors.

Its purpose would be achieved when all minerals engineers and their associates would be enrolled in the Institute, and its prestige established to a point where it could then seek for improvement of both the material and spiritual recognition of the profession.

Since the basis of Engineering is technical knowledge and experience in the many diversified fields of the profession, it is then up to the three Societies, and their even more specialized Divisions and Conferences, to foster this technical sphere of activity. Of course the social phase of these smaller groups is even easier to attain in view of the closer relationship between men engaged in the same specialized field of activity.

The Local Section has a different function, in that it brings together at closer intervals engineers whose fields of activities are diversified, but whose residence is the essential basis of their association. The Section should have a broadening effect on the engineer, in that he can present his own problems to his colleagues in other fields, in that he can thus realize his relationship to the entire field of minerals engineering, and thus sally forth from his own technical tower of ivory into the larger world.

But all of these, National Institute, Societies, Divisions, Local Sections, should afford the individual engineer the chance to participate in their work. As will be brought out further, the individual has certain responsibilities to the group; it is up to the group to furnish the occasion and to encourage the discharge of these responsibilities through presentations, committee work, administrative offices, etc.

Due to the highly specialized aspects of his knowledge and activity, the professional minerals engineer, be his title that of mining, metallurgical, petroleum, geological, or be he simply a graduate of the school of *hard knocks*, has certain specific responsibilities to society in general and to his employer in particular. He is very much like a doctor or a lawyer in that he is in a position of trust for which he was hired to accomplish certain results, in which the technical details are left, perforce in many cases, to his ingenuity, ability, honesty, and responsibility. He is therefore part of the *management team*, although it may appear to him, at least in the early training stages of his professional development, that he is neither fish nor fowl.

The broadening influence of the diversified interests of the engineers who belong to a Local Section because of their residence in an area is essential to the engineer if he is to fulfill his own development as a member of society, of a professional group. He must learn to see the forest not the trees. On the other hand he should contribute of his own in a fair exchange of viewpoints and knowledge with his peers. It is a two-way process, a reversible reaction. Since there must be administrative duties, in order for any organization to live, he should assume, wherever he can, his share of the burden of these duties and enter into committee work as his occupation and private life affords.

There isn't one among us who is entirely self-sufficient unto himself, all the more so where the engineer's stock-in-trade is based on knowledge and experience. We are all indebted to those who have preceded us, or to those who work side by side with us for this knowledge. It is a responsibility of the engineer to share his own knowledge, acquired through study or experience, with his colleagues. From a selfish point of view, the individual always receives more than he gives, even if it is only the mere fact that in trying to convince a dissenter he has to marshall his own arguments and thus clarify those facts which, only too often, remain unexpressed in his own mind. Presentation of technical papers, participation in discussions, and exchanging ideas are part of this *share-the-wealth* program which leads to individual advancement in the technical aspect of the engineer's professional baggage.

In his striving for advancement the cooperation of the engineer with his professional society is essential. It is not only in that he advances his own stature and position within the profession, but also that he furthers the profession as a whole. It is not a concept of *class warfare*, but one of compelling better material and spiritual recognition through merit and accomplishment. It is only by the cooperation of each individual with those standards of conduct, by compliance with a code of ethics, and by the wholehearted effort of the individual, that the Institute can attain the position where it can be the spokesman of the Profession. It means not only work for those who can serve as officers or committeemen, it also means interest in the growth, the activities, and the well-being of AIME.

Thus the *reversible reaction* which started on a local, sectional basis actually extends throughout all of the Institute and to each and every member. It is only by this exchange of services that the engineer and his profession may advance towards fulfilling the definition offered above.

—Charles E. Golson

A NEW record in mineral production was registered for the year 1956. Output was valued at $17.3 billion, a substantial gain over the 1955 total of approximately $16 billion. The increase was mainly due to greater production, said Secretary of the Interior Fred A. Seaton, but some contribution to the higher value was made by an increase in the price of certain commodities.

The value of fuels rose 11 pct. Nonmetals gained by 10 pct; and metals, because of greater output of copper, lead, and zinc, rose 9 pct.

Demand for copper early in the year drove the price to a 90-year high of 46¢ per lb, a level that was maintained until July. When supplies met demand the price fell to 36¢ per lb and by year-end some producers were slowing their output. A recent further drop in price may force more cutbacks.

Titanium sponge production almost doubled during the year and with it prices of the metal dropped from $3.45 per lb at the beginning of the year to $2.75 in December. Similarly, prices dropped more than $2 per lb on some mill products. Rising demand boosted domestic output of rutile to about 12,000 tons and imports reached a record 37,458 short tons. Greater production permitted much increased efficiency.

Bauxite production about equaled 1955 output—1.8 million LT. Imports rose 15 pct to an estimated 6 million tons. A record 1.7 million tons of primary aluminum was produced despite the August strike which caused a loss of about 75,000 tons of material. By year's end, production was rated at 1.78 million tons annually. If projected plant construction now underway meets its schedule, primary aluminum capacity will rise to 2.5 million tons annually by the end of 1958.

Eight pct less iron ore was produced in 1956 than in 1955. Strikes caused a shutdown of most mines for about 70 days in midsummer. The loss was not made up by a record rate of production in the last half of the year and extension of the shipping season on the Great Lakes. Imports of iron ore constituted approximately 24 pct of the total supply.

Mine shipments of chromite decreased in spite of incentive prices in a field of expanding demand. Imports made up more than 90 pct of new material.

Domestic manganese output is estimated at 14 pct higher than the previous year, and premium prices were paid by the government. Foreign prices jumped sharply, partly because of reimposition of Indian export duties, and partly because of rising freight costs that followed the closure of the Suez Canal.

The major molybdenum producer processed material of a lower grade and domestic production of the metal dropped off. But domestic consumption and exports were higher than in 1955.

More tungsten was produced than was needed. To make the adjustment to market conditions easier for domestic operators, the government provided for purchase of an additional 1.25 million short tons of tungsten trioxide at $55 per ton.

An increase was seen in output of almost all nonmetals. The upstep went hand-in-hand with growth in the ceramic, chemical, construction, and fertilizer industries.

Values for the three major mineral groups are listed in the following table:

U. S. Mineral Production, 1955-1956

Nonmetallic minerals	**1955**	**1955**
Fuels	$10,846,000,000	$11,805,000,000
Other	3,083,000,000	3,292,000,000
Total nonmetallics	13,929,000,000	15,097,000,000
Metal minerals	2,041,000,000	2,239,000,000
Grand Total	15,970,000,000	17,336,000,000

"DURING the last ten years our labor and supply costs have risen about 100 pct," said J. D. Bradley, president of the Bunker Hill Co. recently, "whereas the prices of lead and zinc have only increased 15 pct. The fact that lead-zinc producing companies have maintained a reasonable profit performance under these conditions is a real credit to the industry."

He said that the outlook for lead, despite an "unexciting recent history," appeared substantially brighter than it had in the past. Increased consumption is evident in tetraethyl lead, lead oxides, storage batteries, solder, and atomic shielding. Moreover, he noted, use losses of lead in the paint, foil, and cable industries have seemingly reached their low point.

President Bradley also put emphasis on the strong growth rate in die casting and galvanizing uses of zinc. The future for special high grade material looks especially good, he said, pointing out that while the zinc industry as a whole had grown 30 pct in the last 15 years, the consumption of special grade zinc for die castings had increased by six times this rate.

High grade zinc has a bright future on the world level as well, he said. "During the past four years, Great Britain, France, Germany, and Italy, have increased their yearly per capita usage of zinc for die casting from 0.5 to 0.8 lb, or 60 pct. At the same time the U. S. has registered a gain of from 3.0 to 4.9 lb, or 63 pct." The lag per capita between the four countries mentioned and the U. S. is still 4.1 lb, but the gap is expected to narrow as world living standards rise. In line with this rise and ignoring new uses, he declared, there is reason to believe that the current oversupply of both lead and zinc will be absorbed. But because prices have not advanced as fast as costs, research programs are being sharply expanded by lead-zinc companies and associations.

SUMMATION of the natural resources and economics of all the countries of the Western Hemisphere is contained in Senate Document 83 which is available upon request from the Committee on Interior and Insular Affairs, United States Senate, Washington, D. C.

The 619-page volume covers factors affecting self-sufficiency in materials within these nations and was undertaken pursuant to a Senate resolution to investigate the accessibility and availability of supplies of critical raw materials. A similar document, limited to the U. S., was made available at the Annual Meeting two years ago but such distribution of the new report was not practicable this year.

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CERTIFICATES of management excellence for 1956 were awarded to 410 American and Canadian companies this year by the American Institute of Management. Using a point schedule which requires 7500 of a possible 10,000 points for an excellence rating, basic categories of performance judged are: economic function, corporate structure, health of earnings, service to stockowners, research and development, directorate analysis, fiscal policies, production efficiency, sales vigor, and executive evaluation.

Among the companies receiving the awards are a large number which are concerned with primary metal and non-metal production as a principal activity or which number such production among their major activities. These firms are: Aluminium Ltd., Aluminum Company of America, American Cyanamid Co., American Metal Co. Ltd., Armco Steel Corp., Bethlehem Steel Corp., Consolidated Mining & Smelting Co. of Canada Ltd., Dow Chemical Co., Freeport Sulphur Co., M. A. Hanna Co., Harbison-Walker Refractories Co., Homestake Mining Co., Hudson Bay Mining & Smelting Co. Ltd., Ideal Cement Co., Inland Steel Co., International Minerals & Chemical Corp., International Nickel Company of Canada Ltd., Johns-Manville Corp., Kennecott Copper Corp., Lone Star Cement Corp., Minnesota Mining & Mfg. Co., Monsanto Chemical Co., National Gypsum Co., National Lead Co., New Jersey Zinc Co., Newmont Mining Corp., Noranda Mines Ltd., Pennsylvania Salt Mfg. Co., Phelps Dodge Corp., Pittsburgh Consolidation Coal Co., St. Joseph Lead Co., Texas Gulf Sulphur Co., Union Carbide & Carbon Corp., U. S. Gypsum Co., U. S. Smelting Refining & Mining Co.

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AN anniversary salute is due the U. S. Coast and Geodetic Survey which this year celebrates 150 years of land and coast surveying and charting. Its value extends to many fields—from tide tables for bathers to starting points for surveyors. Its course over the years has been marked by patient accumulation of vital data and by much new information on marine currents, magnetic disturbances, earthquakes, and solar activities. The Survey has set up nearly 400,000 altitude bench marks, and more than 150,000 *triangulation stations* that pinpoint longitude and latitude.

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CONFIDENT plotting of the future course of lithium by direct handling of basic research problems of the industry may result from the recent formation of the American Lithium Institute. The new organization will back an extensive program scrutinizing the uses of lithium and its compounds in the fields of metallurgy, chemistry, nucleonics, and ceramics.

Formed by three leaders in lithium—American Potash & Chemical Corp. (American Lithium Chemicals), Foote Mineral Co., and Lithium Corp. of America—the institute will guide and support projects which will be assigned to various universities and research institutions.

Much of lithium's present importance lies with still classified uses. But more lithium salts are being employed in highly stable *all-purpose* greases, industrial air conditioning units, welding fluxes, enamels, and glass; and the metal itself has been used as an alloying material. Much interest is also focused on newer outlets such as catalysts for the plastics industry and missile fuels.

There is reason to believe that lithium will be no short-term wonder in the mining industry. Even though present operations have adequate reserves for reasonable demands, there are increasingly more solid grounds for greater activity than was evidenced a few years ago when lithium prospects evoked no enthusiasm in most mining firms.

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LONG-TERM usefulness of the Geological Survey's data and interpretations was notable in recent months in the uncovering of a new zinc district in the Copper Ridge in Tennessee, and in new developments in the Blackbird district, Idaho, and the Iron River district, Mich.

Systematic geologic mapping and study of active and potential mining districts was made through 98 projects in 27 states during 1956.

The Survey's annual report cites publication of some 3019 new or reprinted topographic, geologic, and special maps—a considerable increase over the previous year. More than 18,000 different maps are now available in the national topographic series.


HERE'S A MAN-SIZED JOB

Elmer A. Jones

ELMER A. JONES, first president of the Society of Mining Engineers of AIME, is Manager of Southeast Missouri Div. for St. Joseph Lead Co. He truly represents the miners of the Society.

Born in Minneapolis on Aug. 11, 1902, he attended public schools in his native city and graduated from the University of Minnesota School of Mines in 1924 with a degree in mining engineering. Mr. Jones began his career as an engineer with the Minnesota State Highway in 1924 and in 1925-1926 he worked for what is now part of Tennessee Copper Co. in Ducktown, Tenn.

Elmer Jones began his long association with St. Joe in 1926. Before assuming his present position of division manager, he had served the company, successively, as mine surveyor, safety inspector, mine engineer, mine superintendent, and assistant general mine superintendent. During his long career with St. Joe he participated from the very inception of mine mechanization in the district. Two of his AIME technical publications have dealt with this subject and he is considered an authority on trackless mining operations.

Besides his varied career in engineering and his contributions to the professional society, Mr. Jones has been active in civic affairs. His home is in Bonne Terre, Mo., where he has served as a member of his local school board, as well as filling the office of president for seven years. He has been a participant in such diversified groups as the Rotary Club, the Executive Council of Boy Scouts (St. Louis), Rivermines Engineers Club, and the Missouri Athletic Club.

Mr. Jones married Celeste Phillips Jones of Rogersville, Tenn., and they have three sons, Stanley Gordon, James Irvin, and John Thomas; a daughter, Celeste Phillips Jr.; and, to date, one daughter-in-law. When not busy with his many professional and civic activities, he enjoys working in his garden—its tulips and shrubs being his specialty—and occasionally manages to squeeze in a fishing trip.

Sherritt Gordon Nickel Copper Mines

by Alan E. Gallie

Operations at the Lynn Lake plant in northern Manitoba are now a part of Canadian mining practice. These projects present special problems as development continues.

SHERRITT Gordon Co. was formed in 1927 to exploit a copper zinc orebody located in the bush 90 miles north of The Pas, Manitoba. The mine went into production in 1931, operated for a year and a half, and closed because of the low price of copper. Reopened in 1937, it operated continuously until mined out in 1951, producing 8.5 million tons of ore.

From 1937 on Sherritt Gordon conducted an energetic prospecting program throughout northern Manitoba, giving particular attention to the belt of favorable greenstone rocks north of the Churchill River. From 1937 to 1941 a number of gold showings were located but nothing of economic value was found.

In the fall of 1941 Austin McVeigh, one of the company's prospectors, discovered a small showing in a muskeg north of what is now known as Lynn Lake. A splash of massive pyrrhotite and some disseminated sulfides showed, associated with diorite. Specimens assayed ore grade in nickel and copper. But war was taking increasing toll of prospecting activities, and further exploration was left until better times.

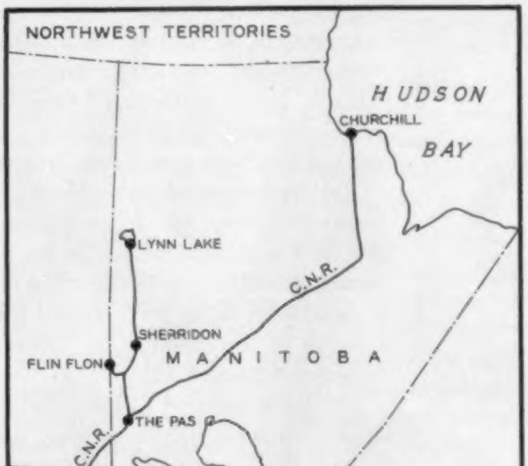
During the late summer of 1945 Tiberg magnetometers located anomalies in the immediate area of the original discovery, and a few boulders were found that contained disseminated sulfides of ore grade. Late in the fall a diamond drill was flown into the area and dragged across four miles of swamp and bush to the scene of the *A* anomaly. The first two holes were unsuccessful, but the third hole, drilled vertically at the highest magnetic reading, cut 100 ft of disseminated sulfides averaging 1.55 pct Ni and 0.69 pct Cu. A systematic coverage of the whole area by Tiberg magnetometer revealed many anomalies, but subsequent diamond drilling indicated that most of these were caused by magnetite.

Some other method of geophysical survey would have to be used. Sherritt Gordon, cooperating with C. S. Davidson, pioneered an electromagnetic method that greatly improved the technique and reduced the number of anomalies to a reasonable figure for diamond drilling. Today 90 pct of all the geophysical work is done with electromagnetic equipment.

The Lynn Lake area is typical of most of the northern Manitoba section of the Pre-Cambrian shield—a peneplain with low relief, almost entirely covered with muskeg, sand plains, and lakes. Muskeg areas are always underlain by permafrost. The forest is mostly black spruce and jack pine—a tree 25 ft high and 6 in. at the butt is considered timber.

Under these conditions prospecting by geophysical methods is the only solution, and except for orebodies recently discovered in the course of underground exploration, all orebodies were located by geophysical work. No outcrop of any orebody is known. The whole property has now been covered by electromagnetic survey and a large part of it by magnetometer. Readings were taken on lines 100 ft apart at intervals of 50 ft. Two thousand and fifteen miles of lines have been cut for this work, and an area of 42.4 sq miles has been covered at an overall cost of \$5212 per sq mile.

The first diamond drilling was done with small machines and EX-size equipment. All supplies for



A. E. GALLIE is Manager of the Lynn Lake plant, Sherritt Gordon Mines Ltd., Lynn Lake, Manitoba.

the early work and the gear itself had to be flown in by small float or ski-fitted aircraft. When winter freighting started, larger diesel machines and AX rods were used.

Anomalies were drilled with one vertical hole located at the best electromagnetic crossover and close to the highest magnetic reading. This was usually found sufficient to decide the value of the geophysical indication. If ore material showed, a section across the zone was drilled with holes on 50-ft centers to a depth of 500 ft. Where it was necessary to drill to 1000 ft, holes were spaced 100 ft apart. Because the orebodies were small, surface exploration below 1000 ft was never successful.

As the picture of the orebodies developed they were generally found to be vertical or steeply inclined, round and small in horizontal section, and associated with considerable faulting. Because of the faulting it was necessary to deepen many of the holes, first removing as much as 150 ft of ice before redrilling. No special technique was needed for the permafrost, however, as underground temperatures were never severe.

By the end of 1946 three orebodies had been located and drilled and 5 million tons of ore averaging 1.18 pct Ni and 0.60 pct Cu had been proved. All of these orebodies were associated with the north intrusive basic plug. Early in 1947 an anomaly was found which had readings up to 15,000 gammas in an area outside the known plug. Although it was considered too high to be an orebody, electromagnetic results were also good, indicating the shape to be roughly circular and 300 ft in diam. Hole No. 160, located on the highest magnetic reading, became the hole that made Lynn Lake a mine. The log is as follows: surface to bedrock, 15 ft; to 37 ft, barren hornblendite; to 639 ft, a core of massive sulfides. Pentlandite and chalcopyrite were both obvious in a ground mass of pyrrhotite. The grade of the intersection was 4.87 pct Ni and 1.71 pct Cu. This hole gave no information on the shape of the deposit, but because of the dimensions of the anomaly it was decided to drill the whole area on 50-ft centers. When the job was completed the *EL* deposit contained 2,445,000 tons grading 2.50 pct Ni and 0.93 pct Cu. Information from this close drilling was so complete that no underground work was done prior to going into production. Subsequent underground development did not alter any of the conclusions with regard to the orebody.

The *EL* orebody was peculiar in that it was found in a small basic plug of 1300-ft diam entirely separate from the other plugs. The country rocks outside the plug are sediments, the main mass of the plug is diorite, and a core of amphibolite enclosed the orebody itself almost exactly in the center of the structure.

Surface drilling on the main property at Lynn Lake now totals 41 miles, almost entirely AX size, at $2.73 per ft. Underground development drilling totals 29 miles, EX size, at $1.93 per ft.

As importance of the discovery increased, it became obvious that a considerable development program would be required. The only means of transportation was by rail to Sherridon and from Sherridon by plane for a distance of 120 air miles. Cost by plane was about 10¢ per lb, and the size of available aircraft placed limitations on what could be moved. Early in 1946 a tractor road was cut through to Lynn Lake, crossing low, flat muskeg areas and connecting with lakes wherever possible. For winter freighting with tractors, 4 ft of ice on the lakes is desirable.

In the fall, as soon as the lakes are frozen thick enough, snowmobiles are put on the road to tramp down the snow and allow the frost to penetrate well into the road bed. When the ice on the lakes is about 2 ft thick, a light tractor outfit called the work crew begins dragging the portages, filling pitch holes, and generally improving the trail. By the first of the year regular freighting gets under way. The unit of transportation, called a *swing*, consists of three tractors, each hauling up to six sleighs; one unit hauls a heated caboose-bunkhouse where the cook holds forth. Operation is continuous, with a crew of six drivers and two brakemen working 4 hr on and 4 hr off.

The best power unit is a D6 Caterpillar tractor. International TD18's are also used, and on good roads and lakes a special type of ski-steered crawler tractor called a Linn tractor can haul tremendous loads, traveling up to 11 mph. A Caterpillar machine is wide open at 4 mph.

The specially constructed freighting sleighs are loaded to about 8 tons each. Special equipment and extra heavy pieces weighing as much as 30 tons are hauled on sloops and slide directly on the road.

The number of swings varies according to the tonnage to be handled in any year. In the two big tonnage years eight swings were on the road all season. At the end of the railroad a crew made up the loads and yarded sleighs. When a swing came in from the north the empty sleighs were dropped, the cookhouse was backed up to the woodpile, and the tractors were sent to the garage for greasing and oil change. As soon as the machines were ready, the loaded strings of sleighs were hooked on, the caboose was attached, and another trip was under way. Some 48 hr later the swing pulled into Lynn Lake, dropped its loads, hooked onto waiting strings of empties, and in an hour started on the return journey.

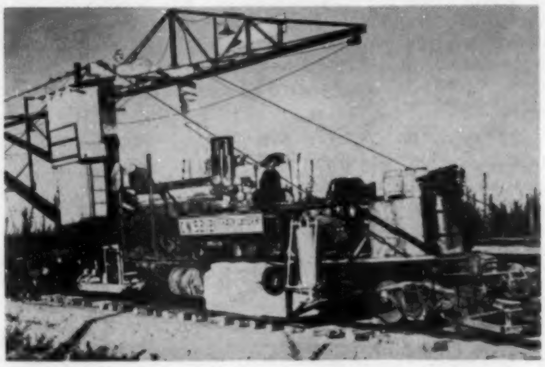
With each succeeding year, as the scale of operations increased, more and more material came in over this road. When the decision to go into production was reached and the Sherridon plant began its trek to the new mine, tonnages went as high as 12,000 tons in a single season. Finally, when the town of Lynn Lake was organized, nearly all the town of Sherridon was successfully moved over the road—houses, two-story buildings, the school, two churches, the bank, and the post office. All maintenance supplies and all the construction material for the mining and milling plant—more than 40,000 tons—came in over this road.

Winter freighting like this is not without danger. On two occasions lives were lost when machines went through the ice. The salvage operation that follows the loss of a tractor through the ice is a story in itself. It is enough to say that no tractor remains in the bottom of a lake on the Lynn Lake road, despite the fact that in a particularly bad ice year six were in at one time.

Most of this great freighting job was done on contract by the Patricia Transportation Co. The overall laid down cost per ton of freight over 165 miles of rugged winter road in a cold and tough country was $56.

Preliminary surveys had shown that the best rail route would be a continuation of the existing branch line at Sherridon, a distance of about 145 miles, with three large bridges to cross the Churchill River.

ABOVE: Sherritt Gordon Mines Ltd. plant at Lynn Lake, Manitoba. RIGHT: Lynn Lake area. Typical peneplain of the northern Manitoba section of the Pre-Cambrian Shield.



ABOVE: Longhole drilling setup at Lynn Lake. UPPER RIGHT: Specially constructed sleighs have capacity of 8 tons. LOWER RIGHT: Canadian National Ry. tracklayer, the *Pioneer*.

The Canadian National Ry. agreed to build a line if enough ore could be found to operate a plant on a scale of 2000 tpd for 20 years.

Since five orebodies had been found from surface and tonnages proved to 1000 ft, it was decided to go underground in the area of the *A*, *B*, *C*, and *E* orebodies and open these deposits on the 1000 level. Additional drilling could then be done from this horizon to explore the ground for the next 1000 ft. No underground program was undertaken at the *EL* orebody because the tonnage possibilities here seemed to be limited.

At *A* mine, the only appropriate site, a shaft was sunk to 1000 ft and later deepened to 1627 ft before production started. Mucking was done by hand. This five-compartment shaft consists of two skips, a large cage, a counter balance and pipe compartment, and a ladderway. Fir timber 8 x 8 in. was used throughout with sets on 6-ft centers. Cost of the completed shaft was $314.90 per ft. The *EL* mine was later opened by a small three-compartment shaft at a cost of $167.16 per ft.

For the purpose of comparing Lynn Lake figures on specific work with costs at other operations, freighting costs were kept in a separate account and never redistributed. Unless specifically mentioned, therefore, no winter tractor freight charges are included in the cost figures presented here.

One level, the 12th, was opened on the 1000-ft horizon, exposing the *A*, *B*, and *C* orebodies. The *E* orebody was found to bottom just above the 12th level. Feed for a pilot mill was obtained from each orebody. Local wood at $14.50 per cord was burned to supply steam for hoisting, and diesel power supplied compressed air and electricity. Drifting costs were high—$50.58 per ft.

By the end of 1950 ore reserves stood at $14,055,-000 tons, grading 1.22 pct Ni and 0.62 pct Cu. The Canadian National Ry. prepared to build the railroad.

Further search for ore was abandoned and every effort was made to get the mines ready for production. Pilot plant operation had shown the ore amenable to high grade flotation concentration with good recoveries, and equipment from the 2000-tpd mine at Sherridon was ideally suited to Lynn Lake. With the development of the Forward process Sherritt Gordon had eliminated the need for a smelter at the mine—concentrates would be turned into metal at a chemical plant on the prairies situated close to natural gas.

On Sept. 17, 1951, the last ore went through the crusher in Sherridon. In September 1953, just two years later, the first ore went through the same crusher at Lynn Lake. The nickel spike was driven on Nov. 9, 1953, by the president of Canadian National Ry. in the yard behind the mill as the first concentrate was being loaded into railway cars.

Preliminary surveys had shown the feasibility of developing power for the project on the Laurie River, 45 miles south of the mine. The Laurie River development now comprises a concrete dam and a powerhouse with two 3500-hp turbine generators operating under a head of 55 ft; two upstream storage dams; a diversion dam; and a 69,000-v transmission line. The total cost of $4,088,000 includes all winter freighting costs. Other sites on the Laurie River can provide for any needed expansion up to 18,000 hp, and the transmission line has been designed to carry all the power that can be developed.

Costs Per Ton at the Lynn Lake Plant

Direct development at *A* and *EL* orebodies	$0.39
Stoping and handling	$1.42
Surface crushing and concentrating	$1.07
General expense	$0.90
Total	$3.78
Surface exploration and other development	$0.26
Total mine costs	$4.04

Two mines are in production and two orebodies are being mined to date—the *A* orebody and the high grade *EL* orebody. The *A* mine operates at 1500 to 1700 tpd and the *EL* mine at 700 to 800 tpd. A 25-ton diesel electric locomotive hauling 10-ton Granby-type cars carries ore from the *EL* mine to the concentrator at the *A* mine over a narrow-gage railway 2½ miles long.

The orebodies are pipelike and nearly vertical, with good rock walls, and lend themselves to open stope mining with sublevels at 75-ft intervals. Primary breaking in the stopes is done by longhole ring drilling with tungsten carbide bits, sectional steel, and 4-in. percussion machines. Drilling is done from 8 x 8-ft peripheral drifts or crosscuts. The original slot between sublevels is made from vertical 4 x 4-ft raises driven well ahead of stoping without the aid of timber, and the opening is completed by breaking through from above. The law permits driving these untimbered raises to a height of 60 ft.

Ore is drawn from stopes through nearly horizontal scrams. Originally these were finished with concrete to 7 x 9 ft including wear rails in the bottom and sides, but if scrams are used again they will be left raw. Drawpoints are on one side only, on 30-ft centers, and are 6 ft wide by 5 ft high with 45° bottoms. The most successful mill holes, about 30-in. diam, are made with discarded lines from the 5½-ft shorthead crusher. Sixty-horsepower electric hoists supply the scraping power, pulling 60 or 66-in. scrapers, the smaller in the extremely heavy high grade at the *EL* mine. Both folding and box-type scrapers are used.

The scrams discharge to orepasses feeding directly to the jaw crushers, which in turn discharge onto 30-in. conveyors to the loading pockets. Conventional skips handle the ore to the headframe bin.

At each mine 5000 to 7000 cfm is delivered through a ventilation shaft connected with the tail end of every scram. There is always fresh air in all working places in the mine. In winter when the temperature falls to 50° or 60° below, a 150-hp boiler at the *A* mine and an 80-hp unit at the *EL* mine heat the required air so that it can safely be taken underground.

During 1955, when the plant operated at capacity, 761,000 tons of ore were hoisted, at a rate of 2087 tons per calendar day, 22.71 tons per manshift underground, and 6.22 tons per man on the payroll.

Blasthole drilling yields 4.2 tons per foot of hole, with a primary powder factor of 0.35 lb per ton and a secondary powder factor of 0.18 lb. One of the advantages of the system is a year-end figure of 382,000 tons drilled off and ready to blast.

Production has been carried out on the fringes of the north, on the edge of the barren lands, and costs are shown to be reasonable. It can be expected that more and more mines will be successfully operated in the northern extremes of the continent.

Longhole Method of Mining Anthracite

by G. H. Lovell, W. J. Parton, and J. J. Crane

IN 1949 Lehigh Navigation Coal began a study to improve its mining methods. At this time the company mines were using conventional breast and pillar and slant chute methods to mine the steeply pitching coal (40° to 90°). Mining costs were high, the miners' productivity low. There were many hazards typical of the methods employed.

Coal seams in the Panther Creek Valley area of the southern anthracite field form a syncline dipping 40° to the south and 75° to 80° to the north, the lowest point 1500 ft from surface. Several contiguous veins 7 to 50 ft thick are mined. Characteristic folding is shown in Fig. 1.

Studies indicated that considerable time would be needed to adapt continuous mining and other mechanical methods to prevailing conditions in the area. It was agreed that to mine the anthracite more efficiently the longhole drilling tried in 1937 could be best adapted in a short time. The new method employing this principle was not to be used exclusively for removing pillars between breasts but was to be the chief method of mining, eliminating the past practice of primary and secondary mining. Rock and coal development were to be held to a minimum, and the whole vein was to be drilled, blasted, and removed as rapidly as possible. Application of longhole methods in mining coal of course presented difficulties—there was danger of gas explosions and mine fires from blasting operations, and the presence of methane gas required suitable ventilation systems.

Preliminary Experiments: Success with any mining system employing the longhole method depends on correct use of a blasting technique that permits the material to be blasted to a free-face at right angles to the line of the hole. The free-face toward which the blast is directed is generally obtained by driving a conventional breast or chute and blasting

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Jeffrey A-6-A drill mounted on specially designed column. This type of drill is very light and flexible.

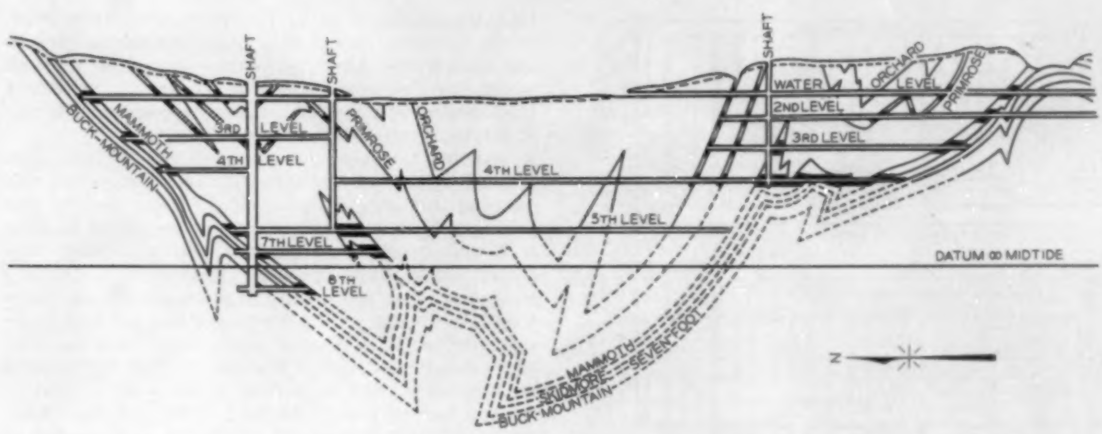

Fig. 1—Cross section showing veins in Panther Creek Valley mine. Thickness of these veins varies from 7 to 50 ft.

into it when it has been at least partially emptied. Loose material is left as a buffer.

Early experiments were conducted on a new level of the No. 6 mine at Lansford colliery. The Mammoth vein on this level was about 45 ft thick and the pitch 41° to the south. The vertical lift to the level above was 100 ft.

Several objectives were set up for these tests. All development, drilling, and blasting were to be done outside the coal seam. Separate crews were to carry out these jobs, and another crew was assigned to load the blasted coal into mine cars on the main haulageway.

Fig. 2 shows the development used for this system. The 8x12-ft haulageway was driven in the Skidmore vein, which lies about 30 ft below the Mammoth vein. Rock chutes were driven off this haulageway on 60-ft centers to the Mammoth vein and were connected by chutes driven toward each other at 33° pitch. The tops of the slant chutes were connected with a 6x5-ft crosscut. Rock holes were driven back to the coal from these rock slant chutes on 20-ft centers, providing taps through which the broken coal would eventually be drawn. A return 8x10-ft airway was driven 12 ft under the Mammoth vein in an elevated position about 50 ft (pitch distance) above the haulageway. This heading was to be used as the opening from which the Mammoth vein would be drilled, charged, and blasted and would eliminate the necessity of driving a development opening in the coal. The ventilation system used 6000 cfm of air, which entered the haulageway and exhausted out the airway, after sweeping through the slant chutes and rock tap openings to the vein.

While the development work was going on in the rock, a breast 24 ft wide with 6x6-ft companion chute was driven along the bottom rock from the sixth level to the fifth level gangway. Cutbacks were taken off every 15 ft as the breast advanced up the pitch. Blasted coal filled the breast to enable the miners to work at the face. This phase of the operation conformed to existing mining practice.

An air-operated noncoring blasthole diamond drill was set up in the drill heading and holes were drilled through the intervening rock into the vein. These holes, bottomed in the top rock or in the gob, were fanned vertically as shown in Fig. 2, with drilling lines on 10-ft centers. One hole was drilled into the fifth level stump gangway to test for the presence of water. After a drill round was completed in the drill heading, the equipment was moved down to the slant chute to undercut the block of coal for loading. This was done by using a burn cut (Fig. 2) of multiple holes near the center.

Drilling the holes in the coal with the diamond drill was not successful. Where the coal was soft and shelly, the water used to remove the cuttings washed cavities in the vein which later caused difficulty when the holes were charged for blasting. Also, the coal cuttings blocked up, damming the water in the hole so that they could not be removed uniformly. A drill equipped with auger drill rods and tungsten carbide bits put an end to these problems and was used for all drilling in coal from that time on.

Permissible explosives were placed in each hole, with Primacord and at least two millisecond delays to insure detonation. (Fig. 2 shows the length of hole and the distribution of powder.) As successive lines of holes were drilled, charged, and blasted, enough coal was drawn off to provide for expansion of the coal mined.

The seam consisted of a 7 to 10-ft section of soft coal on the bottom rock, a slate divider 1 to 3 ft thick, and 35 ft of hard coal above the divider. As the vein was not uniform, recovery with the experimental system was unsatisfactory—when the whole cross section was blasted at once and the broken coal drawn through the taps, the soft material came out first. After all the freer running bottom coal was drawn out, large quantities of gob appeared, beating the harder coal to the drawpoints. It was necessary to remove the gob rock by blasting so that the harder top coal could be recovered.

Since efficient coal drilling equipment was available, it was decided to stop using the return airway as a drill heading. Plans were made to establish openings in the coal seam itself to permit operating the drilling equipment. This eliminated the diamond drilling and also reduced the drilling footage required to develop a block of coal.

New Plan of Development

Present Longhole Mining Method: The new longhole method shown in Fig. 3 uses the same rock development system employed with the preliminary method, but the return airway is now in the Skidmore vein rather than in the rock just beneath the coal seam. Rock chutes on 60-ft centers are driven from the gangway to the coal and are connected by

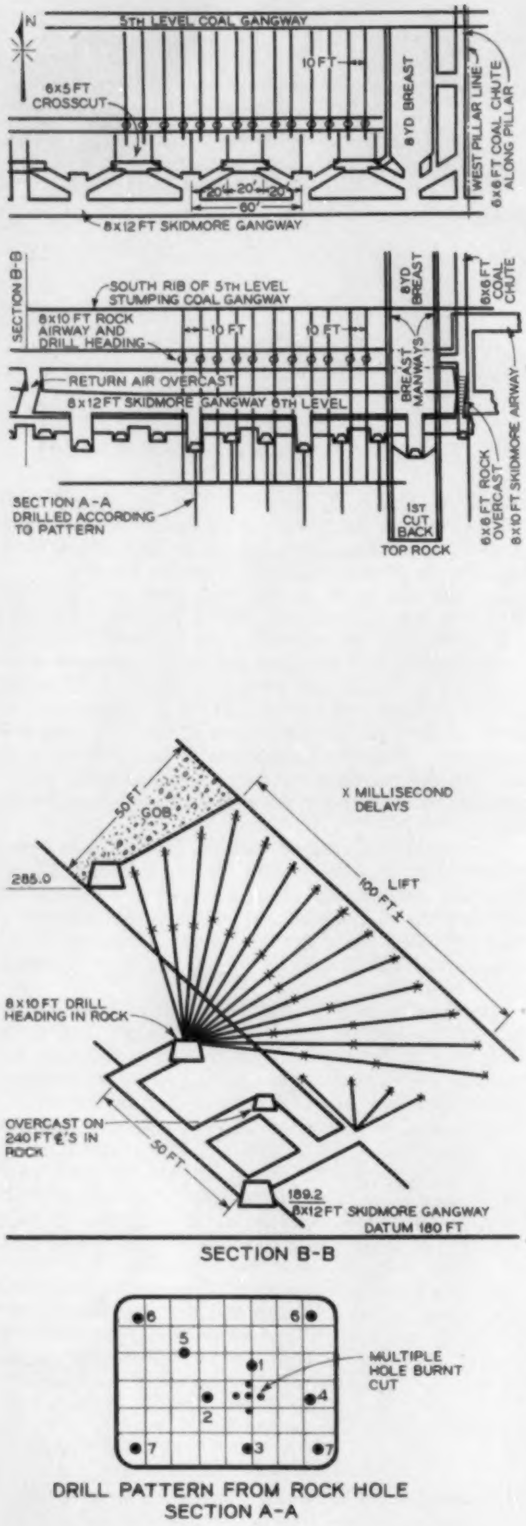

Fig. 2—TOP: Longitudinal section looking north at Lansford colliery. BOTTOM: Original longhole drill mining method at the 6th level of the No. 6 mine and drill pattern from rock hole section A-A.

rock hip chutes 8 to 10 ft under the bottom rock. From these hip chutes rock holes are driven back to the coal every 20 ft, providing openings through which the blasted coal can be drawn. To provide a free-face or opening for blasts, a conventional breast is driven through to the level above.

The rock taps are now extended into the coal seam about 8 ft beyond the slate divider. Originally this opening in the coal on top of the slate divider was enlarged by a cut on each side of the chute to form a T-shaped opening, but this extra opening was found unnecessary and was discontinued. Drilling equipment was then set up in the coal opening above the slate divider in the seam and two rows of holes were drilled in a vertical plane from each opening, as shown in Fig. 3, the number of holes depending on the seam thickness. The holes were drilled to the top rock or 8 or 10 ft short of the gob line. Each vertical ring was laid out to give an end spacing of 10 to 12 ft between the holes. Since two rings were drilled from each tap, a burden of about 10 ft was maintained for each ring of holes.

The 20-ft wide block of coal developed by these drillholes is now ready for blasting. However, the charging and blasting can be done only if the 20-ft block next to it has been blasted and enough coal removed to provide a free-face for expansion. Under these circumstances the holes are charged and detonated, with suitable delays to detonate first the outer and then the inner ring. Drawing of the blasted coal is then started. Successive 20-ft blocks can be mined by the same method.

After all the blasted coal above the slate divider has been mined by this procedure the coal below it is removed, and drilling equipment is set up in the chute between the bottom rock and the divider. Only two or three holes drilled parallel to the bottom rock are needed to break this soft lower seam. A battery is then installed on the bottom rock to provide a suitable drawhole through which the remaining coal can be extracted after the holes are drilled and blasted. After the lower seam is loaded out, each tap is sealed off with a brattice to prevent loss of ventilation air through the job or, depending on conditions, the pulling of gob air into the ventilating currents.

To increase total production from the coal seam, it had been the practice at this mine to provide additional free-faces by driving a breast at 240-ft intervals along the gangway. The above procedure was therefore repeated at several locations in the seam at one time.

Thin Vein Application: Fig. 4 shows the plan designed to employ longhole drilling methods to mine a thin, steeply pitching coal seam at the Nesquehoning mine. The seam was 15 ft thick and inclined at 70°. The mining lift was 120 to 140 ft.

The first step in developing this section for longhole drilling is to drive a conventional breast up the pitch to within a safe distance of the level above. One manway of this breast is holed through to the gangway above. The breast is allowed to stand full until just before the first longhole blast. Successive breasts are driven up to 60 ft on 60-ft centers and are connected at the top with 6x6-ft crosscuts, which serve as drill headings for the upper lift. After the upper lift is drilled, the drill is moved to the lower coal slants and the bottom half of the pillar is drilled. Fig. 4 shows the drill pattern.

After the complete pillar is drilled the initial breast is pulled enough to form an opening, and the

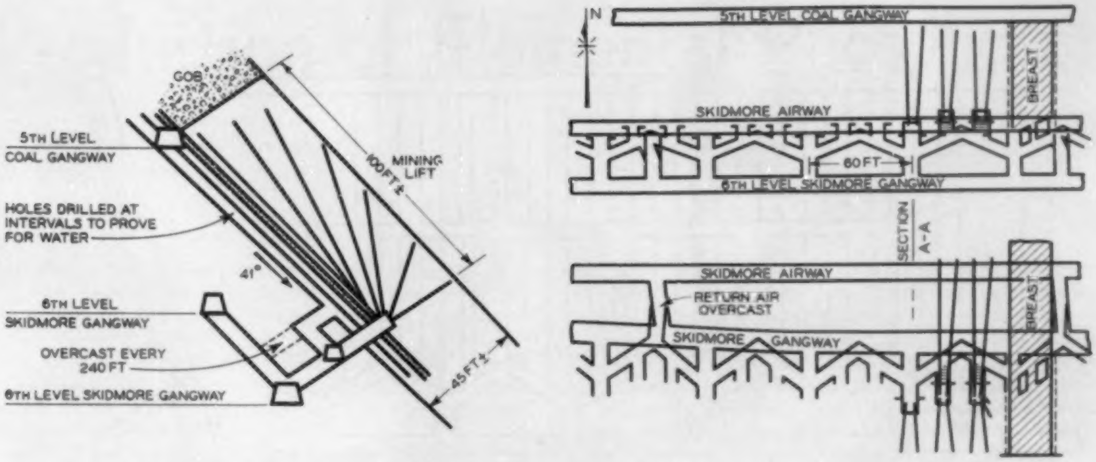

Fig. 3—Longitudinal section looking north and horizontal plan (upper right) at Lansford colliery. Present longhole drill method of mining in the 6th level of No. 6 mine is shown in cross section A-A looking north.

entire pillar is blasted. The coal can then be loaded out through the batteries of the breasts and through batteries that were established in the slant chutes. This method of mining was particularly successful in obtaining high recoveries.

Development of Equipment: Two types of drills, made by Jeffrey and Ingersoll-Rand, are now available for long blastholes. The Jeffrey A-6-A is mounted on a column incorporating a jacking mechanism for quick set-up. The saddle holding the drill on the post permits drilling at any angle and can be easily raised or lowered to adjust the drill at the proper height. The drill advances the bit and drill rods in the hole with a feed bar, and a feed nut engages the bar through a clutch arrangement. This type of drill is light and flexible and has been used very successfully.

The newly developed Ingersoll-Rand 4-S-4 800-rpm rotary air drill employs a 4-ft aluminum feed shell and is powered by an air motor. A pneumatic air column holds the drill in position, and an auger holder keeps auger sections in the hole while the feed shell is retracted and a new auger section is added. This drill requires 6½ ft of clearance to operate and permits using 4-ft sections of auger rods. Time spent in changing rod sections can thus be reduced.

For normal longholes, 2-in. Kennametal bits with threaded shanks are used. Kennametal Inc. designed a special hollow threaded scroll-type auger for this kind of work. (Older types of auger sections without threads permitted the holes to wander, making it difficult to maintain the right spacing between holes.) For 5-in. holes large diameter guides are used at 6-ft or 10-ft intervals along the string of drill steel to maintain alignment of the hole and to prevent the steel from whipping when larger holes are drilled.

In wet or damp coal it is particularly helpful to keep the cuttings in suspension by blowing air through the drill rods. Flowing through a special socket into the rods, the air is ejected through holes in the bit or ejected through hollow couplers between the auger rods.

Special Procedures for Longhole Methods

The engineering department prepares a written description and drawings for all the areas where the longhole drilling method is to be used. The Pennsylvania State Mine Inspector is also furnished with the following information:

1) A plan showing the method of drilling in each gangway or coal seam.
2) The amount of explosives to be used.
3) The method of detonation.
4) The distance from the shot to the firing station.
5) The number of men in the mine when blasting takes place.

Charging and Blasting: Since it is usually desirable for the Primacord to extend to the bottom of the hole, it should be attached to the first cartridge entered. A slanting hole about 4 in. long is punched in the cartridge, coming out at the end. The Primacord is threaded through the hole and tied in a small knot, and usually the cartridge is pushed to the back end of the hole by itself and securely tamped. This insures a continuous line of detonation and also makes it possible to retrieve the lead cartridge if the hole is locked and needs cleaning. After the cartridge with the Primacord is tamped at the back of the hole, the remainder of the charge is loaded by pushing into the hole as many cartridges at a time as are considered practical. Any excess Primacord should be pushed into the hole, with additional stemming behind it.

The primer may be located in the boreholes in any one of three recommended positions:

1) Near the outer end of the hole with the detonator pointing toward the back. This is used only when short leg wire detonators are available.
2) At the back of the hole with the detonator pointing toward the collar. This is used where long leg wire detonators are available.
3) Near the middle of the charge with the detonator pointing toward the back of the hole.

To speed up the work of charging, longholes are loaded with specially prepared 20 to 24-in. sticks of permissible powder. These longer sticks also cut down the possibility of foreign material getting between adjacent sticks and interfering with propagation of the explosion through the entire column of

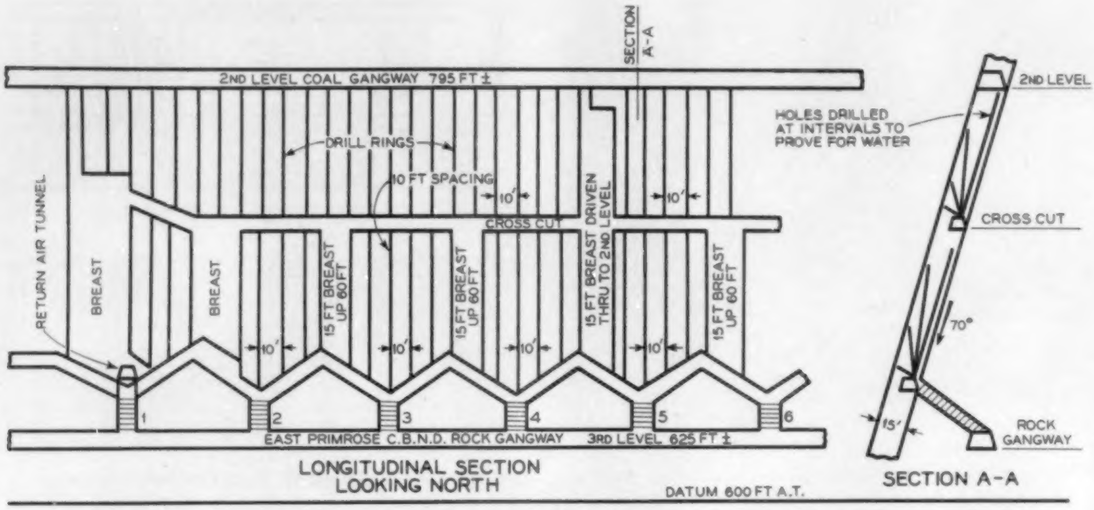

Fig. 4—Longhole drilling method at the Nesquehoning mine. Six rings of four holes 10 to 60 ft long. Charge: 300 lb of Atlas "G" (used with electric delays and Primacord) set off by a 52-cap battery, plunger type. Shot to firing station: 1000 ft.

powder. The powder charge is distributed to equalize the burden on the several holes in the ring and to eliminate concentration of powder near the collars of the holes where they are close to each other. Each hole is detonated with one or more standard delay electric blasting caps with leg wires of varying lengths depending on the depth of the hole. Corrugated asbestos tamping plugs provide the stemming.

The holes are tamped by sectional sticks with lock-hook connections. These connections are made by nonsparking metals—copper and aluminum—and cannot come apart once inside the hole. The sticks are 6 ft long and can be connected or disconnected rapidly.

The charge should be detonated by a 52-cap blasting machine through duplex plastic-covered No. 14-gage firing line from a station located 1000 ft from the shot. There should be at least two right angle turns between the blasting area and the firing station.

Performance Data for Longhole Mining on the 6th Level, No. 6 Mine

Drilling	
Average footage of longholes per day for two miners, drilling exclusively	100 to 250 ft
Average tons, run-of-mine production per foot of longhole drilled	5.75 net tons
Average life of tungsten carbide bits	6000 to 10,000 ft of drilling
Feet of drilling before bits require regrinding	300 ft
Drilling speed per minute	10 to 24 in.
Compressed air pressure required	75 to 90 lb
Labor cost for drilling per net ton of run-of-mine production	\$0.025
Blasting	
Type of powder used	Permissible nongelatinous ammonia (Red H "C" and Globe G-1)
Size of cartridge	1½x24 in.
Type of detonator used	Standard delay electric—no vent—0 to 10. Wires of various lengths
Average cost of blasting supplies per net ton of run-of-mine blasted	\$0.013
Production	
Average run-of-mine tons loaded daily from entire section	1651 net tons
Average run-of-mine tons loaded per miner per day	38.25 net tons
Average of run-of-mine tons recovered from vein	65 to 70 pct

Safety Features: While improvements in many phases of mining were anticipated as a result of this experimental development, one of the principal objectives was greater safety for the miner. The following advantages have been obtained:

1) With the reduction in the number of breasts, the exposure time for miners working in large unsupported openings is greatly reduced.

2) After the initial breasts are completed it will no longer be necessary to remove the accumulated gas caused by blocked manways.

3) Hazards of blasting are greatly reduced because: one large blast replaces a great number of small blasts; charging and detonation are under direct official supervision; and blasting is done off shift, when all other men are out of the section.

Conclusions

The capital investment required to install all the necessary equipment is small. Productivity has increased more than 50 pct and face labor costs have been greatly lowered from the averages obtained with breast and pillar and slant chute mining methods. The hazards of working on the steep pitch have been reduced, and to date no gas explosions or mine fires have occurred from longhole blasts.

There has not been substantial improvement in recovery and yield, and further studies are needed along these lines, but longhole mining has served the purpose for which it was developed. New mining sections are being opened at the Lansford colliery, and all mining on the pitch will be performed by this method.

Acknowledgments

The authors wish to acknowledge the outstanding work done by F. E. Sterner, mining engineer, and his engineering staff; David Crawford, research engineer; and Wilbert Boock and Thomas F. Price, general mine foremen, and their supervisory staffs. Their patient efforts to overcome the many obstacles encountered from the beginning contributed greatly to the success of the longhole mining method. The writers also acknowledge the cooperation and suggestions received from the powder companies and from the many other firms that manufactured the equipment and accessories used.

tions. The thermal process for P_4 recovery is based on the acid activity of silica at temperatures above 1250°C. Without regard to the exact mechanisms

The upper zone of the furnace is, then, a simple packed-bed heat exchanger, where a considerable

Production of Elemental Phosphorus

by V. N. Antaki

ELEMENTAL phosphorus (referred to as P_4) is a true mineral product that has developed, in the relatively brief span of a century, from a laboratory curiosity to a heavy chemical. Annual production now exceeds 300,000 short tons. Continued rise in production has been predicted, consistent with new applications for P_4 derivatives and the expected population increase.

In itself elemental P_4 is valuable chiefly as an intermediate chemical. The principal end uses at present are in inorganic phosphates, both simple and complex, of sodium and potassium, used in water treatment and detergent compounds, leavening agents, food supplements, and dentifrices. Organic P_4 compounds are important as plasticizers, oil additives, flotation agents, and more recently as gasoline additives (TCP being the outstanding example). The increasing use of high-analysis water-soluble and liquid solution fertilizers, as well as the direct application of phosphoric acid to the soil, will probably be the most significant factors in P_4 production growth rate. Coke oven plants now using sulfuric acid to fix byproduct ammonia values will gradually switch to phosphoric acid in order to market a fertilizer with completely available values. Recently sponsored experiments show that phosphoric acid can be directly admixed with cattle and poultry feed to produce rapid growth. Both P_4 compounds and modifiers for oil well drilling mud show increasingly promising significance.

Phosphorite, or amorphous phosphate rock, occurring in sedimentary deposits, usually of marine origin, is the most important mineral source of phosphorus. In turn, the primary mineral constituent in the rock is usually fluorapatite, which has been accumulated and preserved because of its low solubility. Phosphate rock is mined in significant tonnages in various parts of the world, principally in the U. S., Tunisia, Morocco, Algeria, and Russia. Large-scale mining operations in this country occur in Florida, Tennessee, and the four-state area of Idaho, Montana, Wyoming, and Utah. Physical characteristics and chemical composition vary considerably with the location of the deposit.

In addition to fluorapatite, phosphate rock contains varying quantities of other minerals, such as silica, alumina, iron oxide, and vanadium oxide, usually appearing in quantity in the order shown. A number of minor constituents are also present. The ultimate phosphorus content of the ore is defined in terms of percent bone phosphate of lime—$Ca_3(PO_4)_2$—or percent P_2O_5, the latter being more prevalent in the phosphorus industry. Some deposits are suitable for process as mined, but in many instances beneficiation is mandatory. For the electric furnace process a P_2O_5 content of 24 to 26 pct is considered the minimum economical assay; higher P_2O_5 assays are of little practical value, since they must be diluted with silica as a fluxing agent before introduction into the furnace. Of consequence also is the CaO/P_2O_5 ratio in the rock, since as this ratio increases, the quantity of fluxing agent for lime removal must also be increased, leading to increased energy requirements and poorer recoveries. Low iron oxide content is also desirable because the oxide is reduced to the metallic state in the furnace, forming ferrophosphorus (Fe_2P). Usually, the P_4 sale values in ferrophosphorus are not considered attractive.

The fluorapatite molecule, best written as $9CaO \cdot 3P_2O_5 \cdot CaF_2$, is chemically inert under ordinary condi-

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Largest elemental phosphorus installation in the West, this plant near Pocatello, Idaho, is also third largest in the U.S.

riding electrodes. If all particles are too small, gas passage resistance is increased, leading to channeling and puffing, as well as to a deep reaction zone

striving to upgrade their coke production to make more blast furnace grade and less reject. This factor, coupled with the increasing competition for suppli-

tions. The thermal process for P_4 recovery is based on the acid activity of silica at temperatures above 1250°C. Without regard to the exact mechanisms involved, at these temperatures the lime and silica (and alumina) combine to form an inert slag, allowing reduction of the P_2O_5 to phosphorus by the fixed carbon introduced with the charge. Heat must be supplied continually to the reaction.

The electric furnace is an ideal reactor for the process, since large quantities of high-temperature energy can be supplied easily and conveniently. Feed materials can be introduced and discharge products removed without undue complications. In essence, the furnace is merely a covered, carbon-lined crucible, usually with three movable carbon or graphite electrodes entering from the top. Charge enters continuously at the top of the furnace, where phosphorus vapor and carbon monoxide are also withdrawn. Slag and ferrophosphorus are tapped periodically from the crucible. While many electrical and mechanical improvements will continue to be made in furnace construction, very little has been done or can be done to change the basic technology involved in the process. Since the cost of raw materials and energy is fairly well fixed, the industry is resorting to increasingly larger units to effect economies in capital and labor costs. Limiting factors in increasing the size of single units will be discussed later.

It might be added, in passing, that the blast furnace has also been used to produce phosphorus. In this process heat is supplied through the partial oxidation of coke. The high cost of coke as an energy source and the comparatively large volumes of phosphorus containing off-gases that must be treated have eliminated the blast furnace from today's technology.

On the surface, operating an electric furnace appears deceptively simple, but there are many operating variables and many differences in approach, and successful techniques are still an art. This does not mean that some refinement is not being made constantly, but this may be merely a perfection of errors. While it is true that today's electric furnace works, detailed and fundamental engineering analysis is still needed. Such a project is complicated and hindered by the secrecy of the various companies within the industry. Industry-wide cooperation, such as practiced by many metallurgical industries, would be of enormous value.

During operation the cold charge—a suitable mixture of phosphate, coke, and silica—enters the top of the furnace and moves downward as consumed. Gaseous products of the reaction, principally phosphorus vapor and carbon monoxide, flow upward through the bed and exchange their heat with the charge. As the charge approaches the reaction zone in the vicinity of the electrode tips, gradual fusion of the phosphate and silica occurs. In the opinion of many furnace operating people, there is undoubtedly a bed of incandescent coke at and near the electrode tips. As the melted charge trickles through this coke bed, the reduction reaction takes place. The slag and ferrophosphorus remaining as byproducts then join the pools of these materials lying on the furnace hearth. The slag is thought to act as a liquid medium for the reaction. The ferrophosphorus is denser and forms a distinct lower layer, which can be tapped individually. The liquid pools are probably in violent motion because of the combination of reactions taking place and because of the electrode arcs, if any.

The upper zone of the furnace is, then, a simple packed-bed heat exchanger, where a considerable quantity of heat is transferred from the P_4 and CO to the incoming charge. The efficiency of this zone demands that the incoming charge have a good size distribution for gas passage and be physically stable, since decrepitation of the materials leads to channeling, with attendant high off-gas temperatures, increased dust loadings and carryover, and erratic operation. The off-gases must be treated after leaving the furnace, usually by passage through a two-stage Cottrell precipitator followed by a direct-spray hot water condenser. The dew point of P_4 is about 290°C, so that an off-gas temperature of 300°C represents the most efficient operating condition, in so far as heat recuperation is concerned. The adverse gas conditions already mentioned affect operation of the precipitators seriously—extremely high temperatures can bring about structural damage as well as an increase in gas volume and velocity and a decrease in collector efficiency. Solids carried over to the condenser lead to formation of a P_4-containing sludge, which is difficult to break down. (It might be added that cold off-gases mean that P_4 can condense in the treating system; the combination of condensed P_4 and dust can form concrete-like masses which are a source of many operating problems.)

It is of utmost importance to insure that the charge materials are thoroughly mixed before introduction into the furnace and that the relative size distribution of the ingredients is compatible to prevent segregation throughout the feed system and in the furnace. Poor mixing or segregation of the charge leads to alternate over-coking and under-coking and changing silica-lime ratios in the reaction zone. Under-coking usually causes the reaction zone to form lower in the furnace, leading to high electrode consumption and a possible early destruction of the carbon hearth (since both are sources of fixed carbon), poor reduction efficiency (high P_4 analysis in the slags), and higher thermal losses because of increased slag temperatures. Undesirable side reactions can also result. Also, because of the greater depth of the overlying charge, low off-gas temperatures are often effected. Over-coking, on the other hand, causes the electrodes to rise, the most important effect being a sharp increase in off-gas temperatures, with attendant treatment difficulties. This is further aggravated by the unstable electrical conditions that usually result. Over-coking also leads to tapping difficulties because of cold slags and may also contribute to poor reduction efficiency and high P_4 losses in slags. Since silica is so essential to the reaction, excesses or deficiencies have deleterious effects, affecting slag temperatures, compositions, P_4 losses, and ferrophosphorus composition. In an effort to level out conditions, operators often introduce raw charges of either coke, silica, or coke-free burden into the furnace. Such practices merely indicate a more basic deficiency in feeding the furnace.

The ultimate size and size range of the charge constituents is also important. Experience indicates a range of $-\frac{3}{4}$ in. $+\frac{1}{4}$ in. as being suitable, with all materials showing a compatible size distribution. There is some difference of opinion regarding the effects of the differing bulk densities of the various materials. Too wide a range of sizes leads to impaired porosity for gas passage. If all particles are large, too great a porosity results, with lowered heat transmission and dust filtration efficiencies. Decreased electrical resistance also tends to cause high-

riding electrodes. If all particles are too small, gas passage resistance is increased, leading to channeling and puffing, as well as to a deep reaction zone because of the increased electrical resistance.

From the foregoing discussion it can also be surmised that proportioning of the furnace charge materials is critical. Routine chemical analyses of the phosphate, coke, and silica are used to inform the operators of the quantities of each material to be blended. Various continuous and batch-type weighing systems are in use—some extremely simple, some overwhelmingly elaborate. Development of a highly accurate pneumatic load cell has led to the design of very simple, accurate continuous weighing systems, in which the phosphate feed rate is used to index the controllers for the coke and silica, thus effecting true proportional weighing. The furnace charge proportioning system deserves considerable thought, from the standpoint of both accurate weight and even blending of materials. False economy at this point will lead to aggravating and often hidden losses in furnace operation. Such factors as electrode consumption, lining life, P_4 losses in the slag, and unit energy consumption depend largely on the accuracy of the proportioning step.

Use of Raw Materials: With few exceptions, phosphate ore as mined is not a suitable direct feed for a furnace. The usual practice is to subject the phosphate to a temperature from 1100° to 1450°C in a rotary or shaft kiln, sintering grate, or combined grate and rotary processor. Pre-agglomeration in the form of briquetting, pelletizing, or extrusion is often employed. The processing temperature selected is usually at the point of incipient fusion of the ore selected, the objectives being to agglomerate the particles into a range of mechanically stable sizes suitable for furnace feed and to drive off various volatile constituents such as free and combined moisture and CO_2. Western phosphates contain several percent of carboniferous matter, similar to shale oil, which is undesirable in the furnace gas treating system. The heat agglomerated phosphate, usually termed *nodules*, is carefully screened of fines before being sent to the proportioning storage bins. The most desirable phosphate would contain the proper proportion of silica to yield the desired SiO_2/CaO ratio (usually from 0.75 to 1.00), so that no silica would have to be added externally; all other constituents of the ore can be considered contaminants, and the fewer the better. Tennessee and western ores, containing natural binders, are usually amenable to heat agglomeration, while Florida ore, because of the beneficiation process employed, would be more difficult.

The primary source of fixed carbon is metallurgical coke, obtained most usually from steel producers as the fractions not suitable for use in blast furnaces. Anthracite coal, petroleum coke, and bituminous and sub-bituminous char have also been used with varying success. High fixed carbon and low volatile matter content are always desired, as well as low iron content. Coke porosity affects the surface area exposed to the furnace reaction, so that high porosity is desirable—within limits. In general, carbon which is graphitized becomes less suitable for furnace use, since its reactivity diminishes and electrical conductivity increases with increasing degrees of graphitization. Coke that is too conductive causes electrical bridging between the electrodes above the reaction zone and leads to high-riding electrodes with all the accompanying distress. Steelmakers are striving to upgrade their coke production to make more blast furnace grade and less reject. This factor, coupled with the increasing competition for supplies and the general increase in other costs, has caused coke prices to show an ever increasing upward trend. Coke represents one of the major cost items in the P_4 process and is a source of constant worry to P_4 producers. Considerable effort is being devoted to the development of cheaper sources of fixed carbon. Coke is usually sized as desired, dried to less than 2 pct moisture, and screened carefully for fines removal before introduction into the furnace proportioning bins.

The properties obviously desirable for silica are maximum SiO_2 content (95 pct minimum), low iron content, and suitable size range and stability. Silica is usually purchased on a sized-and-dried basis and so can be sent to process as received.

Byproducts credits are an important source of revenue to the phosphorus producer. Principal waste products are slag, ferrophosphorus, and carbon monoxide gas. Slag is useful as a ballasting and aggregate material, and increasing quantities are being used in the manufacture of high quality, lightweight aggregates. A superior mineral wool is made from slag, which has also been used as a liming agent for soil. Ferrophosphorus is used chiefly for steel-alloying, although the domestic market cannot absorb present production. Some interest has been shown in ferrophosphorus as an aggregate in dense concretes for nuclear shielding. The carbon monoxide is usually burned as a fuel or wasted to the air. If it is utilized to any appreciable extent as a fuel in plants requiring phosphate heat treatment, important savings are achieved. Carbon monoxide has not been used commercially as a synthesis gas, although it well might be.

Economic circumstances have forced the industry to design and build larger furnace units, the largest having a 42,000-kva capacity. With three electrode furnaces and the present state of the art, however, a distinct limitation in size is imposed by the current carrying ability of the electrodes. The later, larger units have resorted to 45-in. diam graphite electrodes, merely because they are required to carry the loads; processing costs attributable to electrodes have risen sharply to a point where further increases are not economically justifiable. The electrode industry is now making efforts to increase the available sizes of electrodes and to provide compromise compositions that will at least keep costs in line. Further limiting factors in unit furnace size are found in the off-gas treating equipment associated with the furnace. Where Cottrell precipitators are used, for example, they have already reached massive size and are becoming more expensive.

There is a possibility that nuclear energy will supplant electric power as a direct source of high temperature energy. Improvements in equipment and techniques will become increasingly necessary in this highly competitive industry.

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Author's note: These references offer detailed descriptions of the various steps and equipment used in the electric furnace process and also record the many patents and foreign writings on the subject.

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home that evening, thinking of the day's events, I recalled that whereas most of those present had

A Look at the Prospects of the Mining Engineer

by A. F. Peterson

A. F. PETERSON

Editor's Note: These remarks were presented at the Welcoming Luncheon of the Mining Branch Northeastern Regional Conference, Hershey, Pa., November 1956. Mr. Peterson, AIME Member since 1940, is Vice President, Bethlehem Steel Corp., Bethlehem, Pa. That he knows whereof he speaks is indicated by his background. Starting with Bethlehem as Superintendent of the Cornwall Mines in Pennsylvania, he later became General Manager of the Cornwall Div. and in 1946 was appointed General Manager of Raw Materials Properties for Bethlehem Steel. Vice President in 1948, as well as president of various subsidiary companies, Mr. Peterson advanced in the same year to a position as director of Bethlehem Steel Corp.

MUCH has been said and written about the engineer shortage. The mining branch in engineering has lagged during the past several decades. I can think of two institutions, formerly prominent in that field, that have discontinued this department and another that has branched from a purely mining school into various forms of engineering. *Conversely, I do not recall any institutions that have added mining to their curricula.*

I believe that this action is in direct response to the demands of incoming students. But I also believe that while there is a specific demand for civil, mechanical, and electrical engineers in the highly complicated mining operations of today, our need for mining engineers capable of assuming top responsibility for mining operations is unchanged.

So it is up to us in the Institute, and to the mining industry, to make the outlook appealing to the student as he enters college, and to sustain his interest until he becomes firmly established. If we will make a real effort to put our house in order, and then show how interesting and rewarding a mining career can be, we will arouse an interest in the future prospects and thereby obtain sufficient new timber for our needs.

During his senior year the college student is now apt to be besieged with job offers (that is, more than one) from industry. It may well be that in no future period will his popularity reach so high a peak. The next several years, however, may be a period of disillusionment and frustration for the young mining engineer on his first job. The glowing start of a career may seem to tarnish. And for an indefinite period he may feel that he has been taken in. That he is going through *spring training* may not be apparent to him, and in some cases with reason. If we can help to ease his state of mind, as well as his economic situation, during this time of suspense, industry and the profession will be extending a very necessary helping hand. And we will be doing ourselves a service as well.

For his part, the recent student must be indoctrinated with and understand the idea that his days of study and application are not over. Some students have the time and money to extend their normal college course by one or more years, thus becoming specialists in fields of work where, by and large, jobs are readily available. Most of us cannot do this. We can, however, accomplish specialization on the job, but must expect to take more time in the process. This requires a lot of careful planning and much determination on the part of the man. It is not as

simple as registering at the beginning of the school year. It can be done if the will power is there, however. First, we must join, if we have not already done so, and contribute to the activities of the local chapter of the AIME. In 1916, Professor McCaffery, head of the mining department at the University of Wisconsin, urged my class to become student members of the Institute. Since the annual dues were five dollars, this was no decision to be treated lightly and some of us wanted to know what we would get out of it. He replied, "As much as you put into it."

I did not then fully appreciate what he was saying, but I think I do now. Attend local meetings, concern yourself with its affairs, and you will get your money's worth. Do it willingly and openly. Use the front door, so to speak. The AIME rates high in business and professional circles. Being a member will add to your stature as an engineer, and working at it will serve to increase your interest in mining as a career.

Now, what are some of these prospective fields in the mining game today which are worth cultivating?

Well, there is always the old standby, starting with general engineering duties around a mine, moving into operations, and ending perhaps at the top. I wish to point out, in this connection, that the well publicized shortage has not as yet reached to the presidents and chairmen of the boards of recognized mining companies. Even vice presidents seem to be readily available. Or, one can continue in purely engineering work, and have a satisfying career that can be ample reward for all efforts put forth.

A variation of these means to an end arises in the comparatively recent trend of American mining operations into foreign countries. I am not referring to the precious and nonferrous metals group who seem to have fulfilled the requirements very well through the years, but rather to those in oil, iron ores, and so on, who until recently considered themselves as working in home industries. Here we find huge investments now being made abroad by American capital, investments requiring close supervision in countries that are generally short of managerial talent. But our engineers are not necessarily qualified to take over under strange and exacting conditions either. Here is a field that can be very rewarding to the man who will extend himself beyond ordinary demands on his time, to learn the language, laws, and customs and the historical background of a new land. He should learn to like the people and never forget that it is *their* country. This can be a big order for the young American who frequently has not been exposed to this line of thought.

In recent years a new area of responsibility has devolved on us as mining engineers and managers of mining operations. I refer to the field of employe and public relations. The responsibility was always there, but perhaps we tended to think of it as somewhat secondary in nature. Not any more. Now the question arises, are we mining engineers going to pass this matter over entirely to the lawyers? If so, we may wind up working for them.

It is probably a fact that many of us chose engineering because we like to deal with specific problems. We like to think of our work as an exact science and tend to dislike situations involving intangibles. I will give you an example.

Some years ago, I attended a meeting of about 25 people, chiefly plant managers, where the necessity of working under labor conditions imposed by new laws was the topic of discussion. On my way home that evening, thinking of the day's events, I recalled that whereas most of those present had been glum and disconsolate, there had been some who seemed quite pleased with the prospects. Going a little further, I recalled that every one of these was a lawyer. My next thought was "Why?" and I came up with this answer:

A lawyer lives on trouble, chiefly other people's trouble. Without human-type troubles he has no work. Conversely, the engineer's whole existence is spent in trying to avoid trouble. The plant that is planned correctly and runs smoothly is his symbol of success.

My conclusion was, and I leave this with all of you, but particularly with the younger men, shouldn't we adopt some of the lawyer's mental attitude to our advantage. Admitting our need for technical staff help in these matters, wouldn't it be a good idea for mining engineers to be acquainted with our labor and public relations problems in all their complexity, and be willing to assume responsibility in these fields.

There are additional avenues open to the ambitious man. What I would like to emphasize is: specialization and the opportunity to fashion your career does not end with graduation, and in many cases, it can be done better on the job.

Industry has a definite obligation in this picture. It must provide an atmosphere favorable to such thinking and doing. The supervisor who is so self-centered that he stymies the advance of a superior draftsman or surveyor should be spotted by top management and purged. Promotion must never be denied because a man does his job better than his replacement may do it. We must avoid placing a good man on a road that leads nowhere. Frequently, such jobs seem more attractive initially, salary-wise, which merely makes them more deadly to the unsuspecting engineer who awakens much later to the knowledge that he is on a treadmill.

We must not over-staff this group of men, who we may call specialists-in-training, unless we are willing to lose their services to our competitors. It is disheartening to the man raring to go who sees too many young men ahead of him on his particular ladder. It is equally disheartening to realize that he is nose to nose with too many contemporaries equally anxious to get in line. When a good manager finds a temporary lull in available work for the men on hand he must put forth special effort to employ them gainfully. If the manager is up to his job, and after a diligent effort cannot find a worthwhile project—then, he does have too many men. So long as there is a shortage no operator can justify this over-staffing.

Finally, we must pay salaries sufficiently large to attract good men. In short, we must meet competition to begin with and reward effort along the way. The recent graduate knows that he must be around for a while before he is worth as much to industry as a skilled workman, but he also knows that he must live in a presentable manner, the cost of which should at least be covered by his salary.

Those of us who believe that the engineer is an incipient manager, and therefore an integral part of management, have an obligation to convince him *by our actions* that we can and will see to it that he is rewarded without our being pressured from without, and that in addition to rewarding merit, we can and will provide him with the opportunity to prove his worth.

Ventilation and Air Conditioning at the Magma Mine

by Bruce Short

HIGH rock and surface temperatures combined with small deep shafts create a difficult ventilation problem. At the Magma operation in Superior, Ariz., booster fans take air off the bottom levels, directing it first through cooling coils and then through the working places and out to the exhaust shafts. All air drawn from the intake shafts below the 3400 level is cooled before it goes to the stoping areas.

Most of the ore mined at Magma has come from steep-dipping vein deposits developed for a maximum distance of 9000 ft along the strike of the vein. At present approximately one third of the tonnage is coming from a new section of the mine where the ore occurs as replacement deposits along a favorable horizon in limestone beds. The deepest mining level is now the 4800.

Surface temperatures in Superior over the past eight years have averaged 52.4° wet bulb and 69.7° dry bulb. Average relative humidity is 27 pct. In August, the most difficult month for cooling and ventilation, average wet bulb temperature is 66.7°, dry bulb temperature 84.6°, and average relative humidity 37 pct. Rainfall over a 34-year period has averaged 17.68 in.

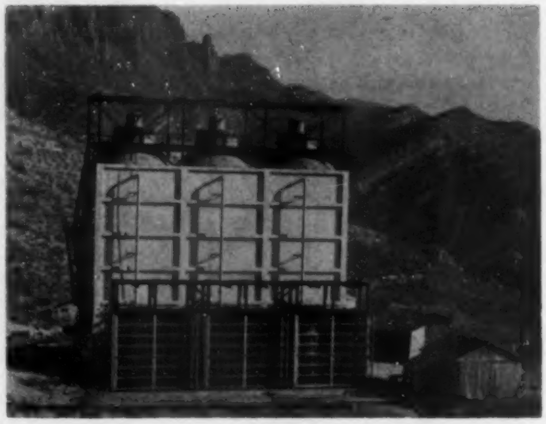
The Magma mine is developed by seven shafts, numbered in the order in which sinking started. Five of these, the downcast shafts, are as follows: No. 5 is a four-compartment rectangular shaft in the west end of the orebody, extending below the 4800 level. No. 3 is a three-compartment shaft in the central portion of the orebody, extending below the 4800 level. No. 2 is a three-compartment shaft located 900 ft north of No. 3 shaft and extends to the 3600 level. These three are the haulage shafts for men, ore, and supplies. All compartments measure 4x5 ft in the clear. Shafts 6 and 7, on the east and west extremities of the vein, are used for intake ventilation only. Both are three-compartment shafts to the 2550 level, and No. 6 has recently been sunk as a five-compartment shaft to the 3400 level.

Shaft 6 is the only intake ventilation shaft with an intake fan. Here a No. 440 backward-curved blade centrifugal fan powered by a 200-hp motor delivers air at 60,000 cfm at 10-in. water gage.

Extending to the 4800 level between shafts 3 and 5, the main exhaust shaft, No. 8, has four 4x5-ft compartments. The centrifugal exhaust fan on the surface, an 8x4 Jeffrey forward-curved blade powered by a 400-hp synchronous motor, exhausts 175,000 cfm at 8.6-in. water gage.

No. 4, the three-compartment exhaust shaft for the east portion of the mine, extends to the 1500 level. A system of raises, winzes, and abandoned stopes provides exhaust airways used in conjunction with this shaft. An 8x4 Jeffrey fan is located on the

B. SHORT is with Magma Copper Co. at Superior, Ariz.



Magma's cooling tower. The 700-ton refrigeration machine is housed in the building at lower right.

500 level but discharges through the shaft to the surface. Powered by a 150-hp motor, it exhausts 115,000 cfm at 3-in. water gage.

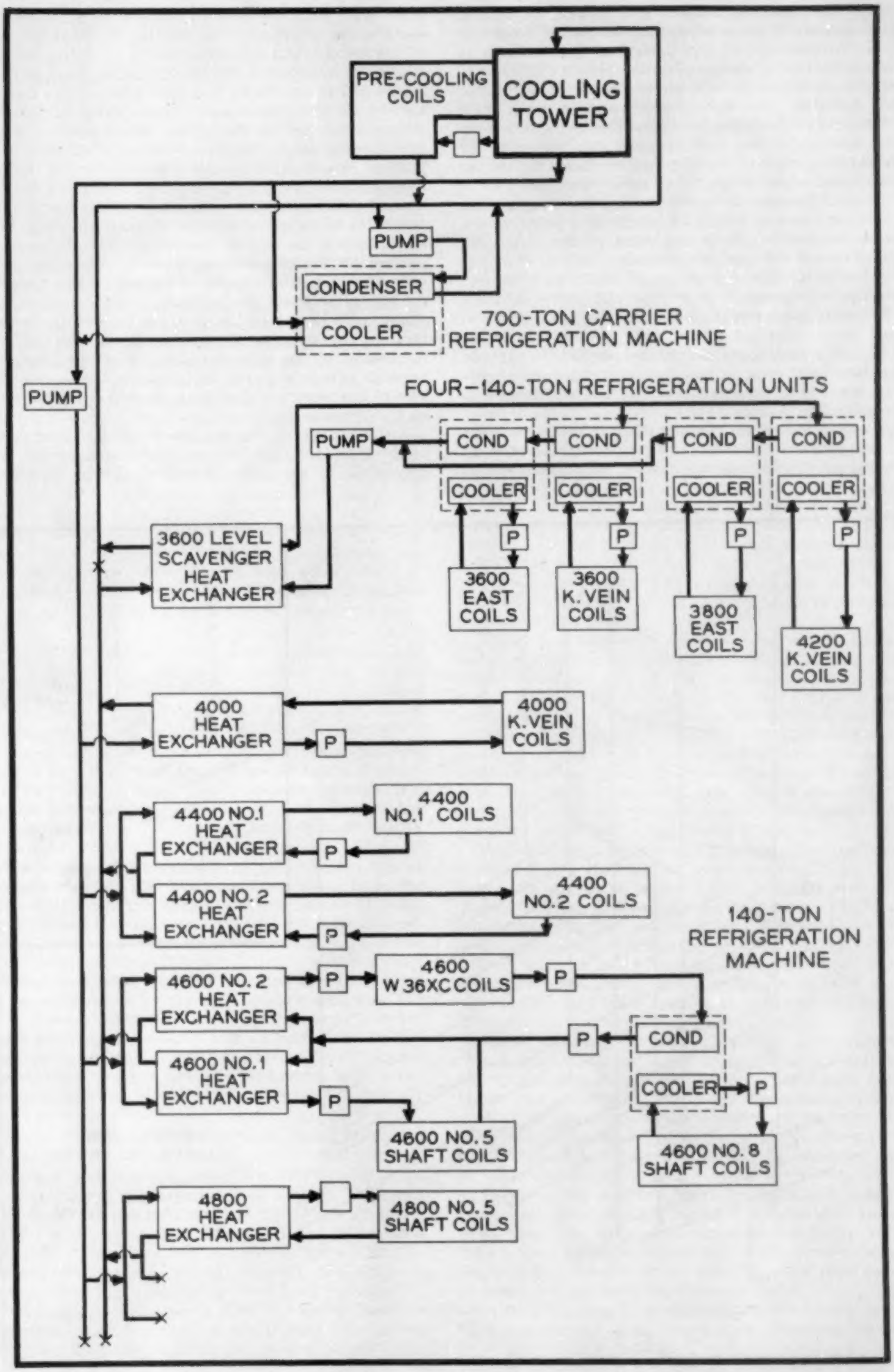
In the ventilation system throughout the mine ten 40-hp fans and eight 50-hp fans also act as boosters. Forty-six smaller fans of 7½ to 20 hp are used for auxiliary ventilation.

Owing to the high resistance to air flow in the ventilation shafts a part of the air is re-used in other stoping areas after it is washed and then cooled in the cooling coils. In this way about 100,000 cfm is reclaimed at a saving of 600 hp. An estimated 1200 hp would be necessary to circulate this additional amount of outside air through the mine, with one and a half times the refrigeration needed for reclaimed air. Also, the increase in pressure necessary to circulate this additional air would call for heavier duty fans and stronger construction in all air doors and brattices throughout the mine.

Fifty-five stopes and 24 development faces were worked in 1955. Average stope temperatures, taken every two weeks by the engineering department, were 84.6° wet bulb and 90.5° dry bulb and average relative humidity was 78 pct. Of the 79 working places 15 were in the East Replacement orebody above the 3000 level. No cooling is installed in this section of the mine, which is ventilated by air coming down No. 6 shaft.

Refrigeration was first installed at Magma in July 1937 when two 140-ton Carrier centrifugal refrigeration machines were installed on the 3600 level. These units were so successful in lowering stope temperatures that five more were installed.

Each refrigeration machine requires about 200 gpm of condenser water. Since only 400 gpm of mine water was available for this purpose, cooling facilities were limited. Before it could be used as

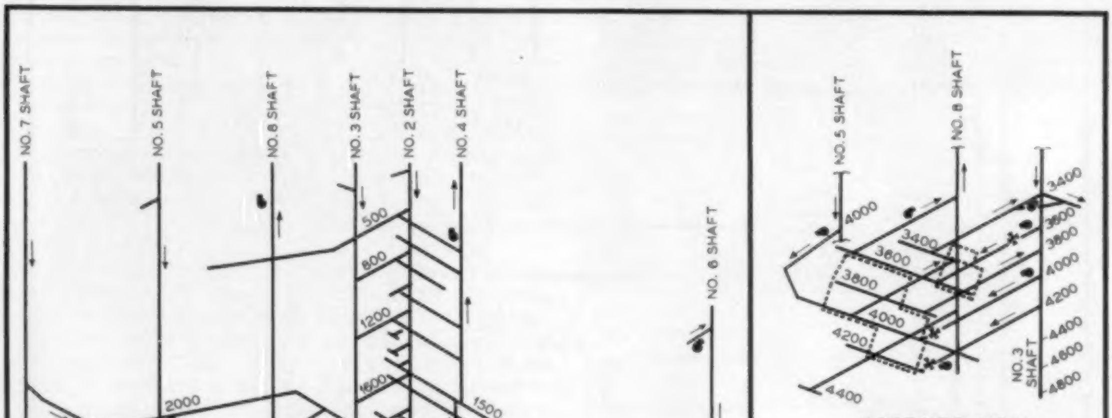

PRE-COOLING COILS
COOLING TOWER
PUMP
CONDENSER
COOLER
700-TON CARRIER REFRIGERATION MACHINE
PUMP
FOUR-140-TON REFRIGERATION UNITS
PUMP
COND
COND
COND
COND
COOLER
COOLER
COOLER
COOLER
P
P
P
P
3600 LEVEL SCAVENGER HEAT EXCHANGER
3600 EAST COILS
3600 K. VEIN COILS
3800 EAST COILS
4200 K. VEIN COILS
4000 HEAT EXCHANGER
P
4000 K. VEIN COILS
4400 NO. 1 HEAT EXCHANGER
4400 NO. 1 COILS
P
4400 NO. 2 HEAT EXCHANGER
4400 NO. 2 COILS
P
140-TON REFRIGERATION MACHINE
4600 NO. 2 HEAT EXCHANGER
P
4600 W 36XC COILS
P
P
COND
COOLER
P
4600 NO. 1 HEAT EXCHANGER
P
4600 NO. 5 SHAFT COILS
4600 NO. 8 SHAFT COILS
4800 HEAT EXCHANGER
4800 NO. 5 SHAFT COILS

condenser fluid, mine water was sprayed down the bottom part of an intake shaft to cool it from the rock temperature of the particular level where it was collected. It was possible to operate four refrigeration machines on this amount of condenser water by splitting the water and running each half through two machines in series. The hot water from the condensers was then sprayed into the mine air exhausting up No. 8 shaft and recooled for use as condenser water in the other three machines.

Use of condenser water cooled by evaporation raised the concentration of solids to a point where scale was continuously deposited in the condenser tubes in the refrigeration machines and in the condenser water lines. This raised the head pressures on the refrigeration machines and lowered their efficiency. After cooling by mechanical refrigeration had been expanded to the limit of available water and more cooling capacity was needed to provide for increased mine production, an evaporative cooling tower was constructed on surface and placed in operation in August 1948.

Cooling Tower at Magma: Magma's 85-ft cooling tower consists of three reinforced concrete cells 24 ft square. To impede the fall of water each cell is filled with redwood decking, supported on concrete piers in the cell basin. The decking starts at the top of the louvers and continues up on 18-in. centers to the water distributor. Eliminator plates made of two layers of 1x4-in. redwood boards offset to the direction of air flow prevent entrained water in the air stream from leaving the tower. Seven rows of copper flashing set in the concrete walls of each cell prevent water from running down the cell walls. A cold water collection sump runs along the entire base of the tower. Any cell can be isolated and shut down for cleaning or repairs without affecting the operation of the rest of the tower. This is accomplished by shutting off the valve to the water distribution system at the top of the tower and closing the valves between the cell basin and the cold water sump. It is then possible to drain the cell basin for cleaning by opening an outside drain. Air enters the bottom of the tower through one of two places—through precooling coils installed on the northwest side of the tower or through a set of hinged louvers on the opposite side.

Air is pulled up through the tower by three propeller-type fans 12 ft in diam. These fans are direct-connected to vertically mounted 40-hp, 25-cycle,



375-rpm motors. Air is pulled through the precooling coils and discharged into the base of the tower by three horizontally mounted fans of the same type, powered by 60-hp motors.

Each cell contains three banks of precooling coils, each bank two coils wide and stacked seven high for a total of 42 coils per cell, or 126 coils for the entire tower. Each coil has a net face area of 25.6 sq ft and is 6 tube rows deep by 20 tube rows high. Tubes and fins are of copper. Four deepwell turbine-type pumps rated at 600 gpm against 85-ft head, each direct-connected to 15-hp motors, pump water from the cold water sump to the top of the tower through precooling coils, counter to the flow of air.

The purpose of the precooling coils is to obtain colder water from the tower. Since the temperature of the water leaving the tower is limited by the wet bulb temperature of the air coming in, to obtain colder water it is necessary to supply the tower with colder air. Pumping approximately 1200 gpm from the cold water sump through the precooling coils lowers wet bulb temperature of the air going through the coils about 6° without changing the moisture content of the air. This air is pulled up through the tower decking countercurrent to a downflow of approximately 2600 gpm of warm water. The water is cooled to within about 6° of the wet bulb temperature of the air coming from the precooling coils. Since this air was cooled about 6° in the precooling coils the water comes from the tower at about the wet bulb temperature of the outside air.

In winter the precooling units are not used and air is drawn into the tower through the hinged louvers. When the tower is operated in this manner the water is usually cooled to within about 8° of the entering wet bulb temperature of the surface air.

Water supply is pumped through a 6-in. pipeline from a well 17 miles west of Superior into a 300,000-gal storage tank near the tower. In summer this water is very warm by the time it reaches the storage tank, but it is cooled in the cold water sump. A pump regulated by a float valve in the cold water sump sends required make-up water to the top of the tower. Water is continuously drained from the return water line to keep the concentration of solids in the tower circuit from becoming too high. Enough water is *blown down* to keep the solids in the water from concentrating to more than two and a half times the original content. Sulfuric acid is added to keep the alkalinity to a pH slightly below 8. The water is also treated with a phosphate to prevent corrosion in the pipelines and certain other chemicals are added to minimize growth algae. Make-up water requirements due to evaporation and blowdown range from 85 gpm on hot dry days in summer to 45 gpm in winter.

Water leaving the cooling tower flows through a 12-in. pipe to the circulating pump near the entrance to No. 5 shaft. This five-stage centrifugal pump is direct-connected to a 500-hp, 25-cycle, 1450-rpm motor. It is rated at 1800 gpm at 610-ft head. A second identical unit is available as a standby. The water is piped down the ventilation compartment of No. 5 shaft, through the heat exchangers on the levels below, and back up the shaft to the top of the tower. The head the pump is operating against is equal to the friction head in the pipelines and heat exchangers and a small static head of 60 ft at the cooling tower. This 60 ft is the distance from the cold water sump to the water distribution network at the top of the tower.

The two pipelines in No. 5 shaft are 12-in. diam to the 3200 level and 10-in. diam below. Wall thickness of the pipe at the bottom is 1 in. There is an expansion loop every 400 ft in both the cold water and the return water pipelines.

The cooling tower is painted with aluminum paint to reflect heat and the tow lines on the surface are insulated and painted with aluminum paint.

At present two sets of heat exchangers are operated on the 4400 level, two on the 4600 level, one on the 4800 level, and one on the 4000 level. Each unit provides water for one set of cooling coils. The two exchangers on the 4600 level also provide condenser water for one 140-ton Carrier refrigeration unit.

Heat exchangers are of shell and tube construction. The high pressure water from the cooling tower flows inside the tubes and the low pressure water to the cooling coils is in the shell around the tubes. A heat exchanger battery for one cooling coil installation is made up of 12 sections connected in series. Each section is 18 ft long and is made up of 64 steel tubes of ¾-in. diam inside a steel shell of 10-in. diam. The high pressure and low pressure water flow a distance of 216 ft countercurrent to one another. Design pressure of the high pressure side is 2500 psi, low pressure side 15 psi. Each heat exchanger battery is designed to cool 215 gpm of water from 89° to 68° when supplied with 250 gpm of high pressure water at 66°.

There are important reasons for using these water-to-water heat exchangers instead of using the tower water directly in high pressure coils. Coils will work near peak efficiency for only one to three years, depending on the percentage of recirculated air they are handling. Oxidation of sulfide particles on the fins of the coils causes the fins to corrode and become brittle. When these fins break off, the coils lose their cooling capacity. For such a short time investment the cost of coils designed for a working pressure of 2500 lb would be prohibitive.

The second reason is the expense of installing this high pressure line. It is sometimes necessary to install these coils as far as 2500 ft from No. 5 shaft, where the high pressure lines come down. While it is possible to install low pressure piping in a standard size drift and still use the drift for haulage, this cannot be done with high pressure pipelines. The large diameter of the flanges required to hold the high pressure and the support to hold the pipe both necessitate extra room.

Pumps with a rated capacity of 215 gpm against 150-ft head circulate water from the low pressure side of the heat exchangers to the cooling coils and back. These lines are filled from the drinking water supply. A make-up water supply is connected to the suction side of the pump to provide for the small amount of water that leaks out through the packing of the pump.

Since cooling was first installed at Magma many types and sizes of coils and coil installations have been tried. At present one standardized size and type is used throughout the mine. Chilled water can be furnished by either the cooling tower or a mechanical refrigeration machine.

Typical Cooling Coil Station: Coils are set in a timbered station with inside measurements 10 ft high, 10½ ft wide, and 10 ft long; in addition an air washer sump 5x5 ft x 3 ft deep is excavated on the

Horsepower Requirements for Operation of Tower and Surface Carrier Unit

Winter operation with three top fans running:
1170 tons refrigeration with 120 hp, or 9.7 tons refrigeration to the mine per unit of horsepower

Spring and early summer operation with precooling units running:
1170 tons refrigeration with 345 hp, or 3.4 tons refrigeration to the mine per unit of horsepower

Summer operation with tower and surface Carrier unit running:
1290 tons refrigeration with 1145 hp, or 1.12 tons refrigeration to the mine per unit of horsepower

Total horsepower requirements for ventilation and cooling:

	Summer	Winter
Cooling tower and cooling units underground receiving water from tower	1165 hp	980 hp
Five 140-ton refrigeration units underground	1405 hp	1405 hp
700-ton surface refrigeration unit	800 hp	
Mine ventilation	1645 hp	1645 hp
Totals	5015 hp	4030 hp

side of the coil station from which the air will enter. A concrete floor is poured and the sides are lagged, covered with asphalt paper and metal lath, and plastered. Two banks of coils, stacked three coils high, are installed. Each coil is 84 in. long, 30 in. high, and four tube rows thick in the direction of air flow. The plate-type fins are of 0.016-in. copper spaced six to the inch. This is a heavier gage fin and a wider fin spacing than is standard for most air conditioning work. The wider spacing makes it easier to keep the coils clean after they become corroded. The heavier fins add to the life of the coils. A pump rated at 175 gpm against 45-ft head takes water from the air washer sump and sprays it through 100 nozzles on the first bank of coils. This removes dust from the air and washes it off the coils and into the airwasher sump, which is cleaned periodically. Chilled water flows through the coils countercurrent to air flow.

The fan moving air through the coils can be on either side of the coils. If it blows air through the coils it must be far enough in front of them to allow the air to spread out and cover the coils evenly. If the fan is on the discharge side it must not be close enough to be wet by the entrained water pulled from the condensate on the coils. When these coils are supplied with 200 gpm at 60°F they will cool 25,000 cfm of air from 85° wet bulb temperature to 69° wet bulb temperature.

Improved Operation of Tower System: After the tower had been in operation it was observed that it could carry a larger heat load and still cool the water to the mine to the same temperature relative to the outside wet bulb temperature. In heat exchangers below the 3600 level, water is heated an average of 12° and is too warm to cool water for direct use in cooling coils. A set of heat exchangers installed in 1950 on the 3600 return water line now provides condenser water for four Carrier refrigeration machines. When this unit started supplying cooler condenser water than had formerly been available to the Carrier units, they operated at increased capacity with reduced horsepower.

Each heat exchanger in the unit installed on the 3600 level is made up of eight sections identical to those in the heat exchangers on levels below. To avoid increasing resistance in the cooling tower circuit these sections are connected in parallel. The high pressure water is heated another 8° in this exchanger. A 100-hp pump circulates approximately 400 gpm through the low pressure side of the heat exchanger, across to the Carrier units located at No. 3 shaft, and return. The water goes across in a 6-in. insulated pipe and returns in two 6-in. lines. Total requirement of 6-in. pipe for the installation was more than 9000 ft.

During the summer months outside wet bulb temperatures average more than 60° and run as high as 72°. Even with the precooling coils in operation, temperature of the water coming from the cooling tower is limited by this wet bulb temperature and is not cool enough to produce the desired amount of cooling in the mine. A 700-ton Carrier unit was installed on surface in 1954 to run in conjunction with the cooling tower and cool the water sent to the mine another 12°. This has lowered the average stope temperatures for these months. Chilled water coming out of the cold water sump at the tower goes through the cooler of the refrigeration machine and is cooled 12°. A 100-hp condenser pump takes the return water from the mine and the water coming from the precooling coils and pumps it through the condenser of this refrigeration machine and on to the top of the tower. Water comes back from the mine 21° warmer than the water going to the mine.

An operator for this machine is in attendance for only 4 hr each day. If for any reason the refrigeration machine shuts down the tower will continue to operate and the mine will not be completely without cooling.

Summary of Surface Tower-Carrier Combination

During the late fall and winter months the tower is operated as a straight cooling tower without the precooling coils. Wet bulb temperatures for these months average below 50°. Water going to the mine averages 48° and may drop to 38° on cold winter mornings.

Usually by the middle of April average wet bulb temperatures are above 50° and relative humidity is down to 20 pct. The precooling coils are then started. When the difference between the wet and dry bulb temperatures becomes about 30° the tower cools the return water down to the outside wet bulb temperature. About June 1st, when the average temperature of water to the mine has increased to about 60°F, the surface Carrier unit is started, cooling the water an additional 12°. During the most humid part of the summer, water comes from the tower at 72° and goes to the mine at 60°. As soon as the tower cools it to 57° the surface Carrier unit can be shut down. Ordinarily this is about the middle of October. Usually by November 10th the precooling coils can be shut down because the spread between wet and dry bulb temperatures is too little for them to be effective.

Filtration and Control of Moisture Content On Taconite Concentrates

by A. F. Henderson, C. F. Cornell, A. F. Dunyon, and

D. A. Dahlstrom

IN processing magnetic taconites several steps of crushing, grinding, classification, and magnetic separation are required to produce a 60⁺ pct Fe concentrate. Usually the final concentrate is in a slurry form of 55 to 70 pct solids by weight and is further characterized by a particle size of 60⁺ pct −325 mesh. In taconite plants already completed or under construction the conventional method used to obtain pellets suitable for blast furnaces is to filter the concentrate slurry, ball the filter cake, and then harden the green pellets in a traveling grate or in a vertical shaft furnace.

Large tonnages must be handled in minimum floor space, with reduced maintenance and lowest possible operating cost. Filtration must therefore achieve two objectives: 1) high filtration rate—in terms of pounds of dry solids per hour per square foot of filtration area—at a low filtrate solids concentration, and 2) a filter cake moisture that will always permit efficient balling within the normal fluctuations of plant operating conditions. If moisture contents are too high, balling may be impossible or result in a mushy ball without enough green strength for the firing operation.

Development work has met these objectives. At low investment and operating costs, filtration rates of 250 to 600 dry lb per hr per ft^2 have been attained for concentrates of 60⁺ pct −325 mesh. By combining the disk-type continuous filter with proper agitation, the Agidisc filter produces a homogeneous filter cake, easily discharged from the disk sectors. This application provides the lowest initial cost per square foot of filtration area, minimizes floor space, reduces down time for changing filter media to a negligible factor, and simplifies process control and maintenance for the operator. It is now possible to predict very closely the taconite concentrate filtration rates for a wide variety of conditions—either by experience or with a few simple leaf tests.

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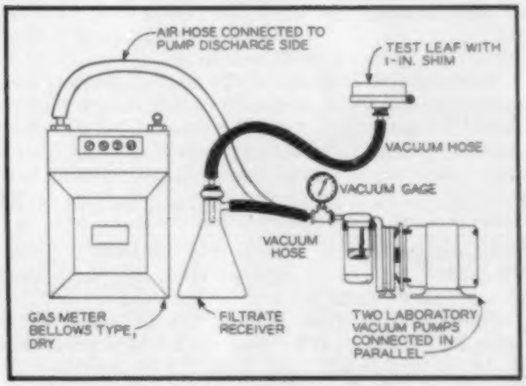

Fig. 1—Laboratory leaf test apparatus.

When balling and pelletizing operations began on a continuous basis, it became apparent that moisture content of the filter cake was a critical factor and must always be controlled by the filter operator below some maximum allowable value. Accordingly the Reserve Mining Co. and the Eimco Corp. joined in a study of the many variables affecting filter cake moisture content. The study was conducted at the Reserve Mining Co. taconite plant at Babbitt, Minn.

To process plant tonnage the Babbitt plant utilizes a 6-ft diam Agidisc filter with six disks and an 8-ft diam drum filter with 10-ft face. However, most of the plant filter investigations were made on the Agidisc because of its superior performance. A considerable amount of small-scale test work was first carried out to study more closely the individual variables and ascertain their effect on filter cake moisture content. A general correlation method was then developed which allowed reasonable prediction of moisture content at any operating conditions. This step was made necessary by the fact that in full-scale filtering, operating variables usually interact to produce a combined rather than a singular effect. Studies were then made on the full-scale filters to prove the validity of the correlations developed, and past operating records were examined to ascertain whether or not significant variations could be traced to any single factor or to a combination of factors.

The Transactions papers appearing in MINING ENGINEERING during 1957 will subsequently appear in AIME Transactions Volume 208 and may be permanently referenced to that volume.

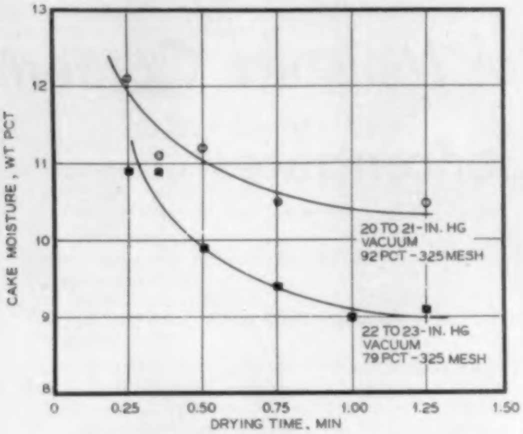

Fig. 2—Cake moisture vs drying time. A 7/16 to 1/2-in. cake at 57 to 59 pct solids, magnetized without dust. Filter media: Saran 601.

Investigation Procedure: To control the test work closely it was decided to obtain all samples of the taconite concentrate from the feed to the 6-ft diam Agidisc filter at the Babbitt plant. To insure further the uniformity of feed samples, all return dust* from the pelletizing section was removed from the filter feed, and this magnetic feed was maintained at a grind of about 88 pct −325 mesh.

* Undersized pellets and dust from screening operation, reduced in size in a ball mill and added to filter feed.

Filtering apparatus used for the tests was a circular leaf, 0.047 sq ft in area, with a tapered bottom designed to give drainage identical to the full-scale filtration equipment. This leaf was fitted with the same media used on the plant filter and a shim which insured that all cake formed on the leaf was a uniform 0.047 sq ft in area. The leaf was connected to a receiver and from there to two vacuum pumps connected in parallel to give a sufficient and controllable air capacity to produce the desired vacuum during the dry portion of the filtration cycle. Exhaust from the vacuum pumps was connected to a totalizing gas meter for air flow measurement. A sketch of this apparatus is shown in Fig. 1.

To determine the singular effect of each variable on the cake moisture, one variable at a time was altered through a given range while the others were held constant. The most significant variables and ranges studied are given in Table I.

After these basic tests had been completed the data were analyzed to establish optimum conditions for obtaining the lowest cake moisture. Several leaf tests were run at these conditions to determine the effect of Separan and Tween 81* and the effect of dust on cake moisture and to compare filter media.

* Two chemical additives that have had success in other fields in reducing cake moisture and/or producing a cake that is easier to handle.

To validate the general correlations of the leaf tests as applied to commercial-sized filters and to investigate more completely those variables found to affect cake moisture content markedly, filtration studies were made on the 6-ft Agidisc plant filter. To simulate leaf test conditions on this filter as closely as possible, studies were made on magnetized feed without dust.

The Babbitt plant has a strict production schedule, and since it is almost impossible to separate variables on a commercial-size filter without making operational changes, it was necessary to do the test work under the particular operating conditions of each day. Slight changes were made in the cycle speed of the filters, but it was impossible to obtain long cycles, which would have reduced productive capacity of the filters. As extensive correlations could not be obtained, comparisons could be made only with leaf test results and the use of a general correlating factor developed from that data. Experimental results obtained from the laboratory leaf tests are presented here. Discussion of the singular effect of each variable on cake moisture is followed by a description of the collective effect of all variables.

Table I. Variables and Ranges Studied to Determine Effects on Cake Moisture

Variable	Selected Test Points
Drying time	0.05, 0.10, 0.15, 0.20, 0.25, 0.35, 0.50, 0.75, 1.00, 1.25, 1.50 min
Cake thickness	5/16, 3/8, 7/16, 1/2, 9/16, 5/8, 3/4, 7/8, and 1 in.
Vacuum: form dry	5, 10, 15, 20, 25-in. Hg 5, 10, 15, 20, 23-in. Hg
Feed temperature	45° through 110°F (10 points)
Size distribution of feed solids	Whatever available (approximately 70 to 95 pct −325)
Feed solids concentration	50, 55, 60, 65, 70, and 75 pct solids
Filter media	Eimco Saran 601
Air rate through the cake	Measured during tests. To be correlated in conjunction with all data

Leaf Test Results

Drying Time: Increased drying time reduces cake moisture in smaller increments, since the decreasing amount of liquid attempts to overcome the large capillary forces present. A graph of this relationship has the characteristic knee-shaped curve that

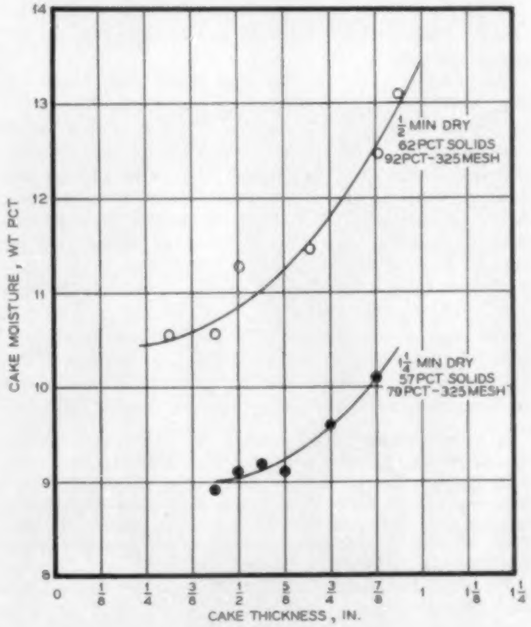

Fig. 3—Cake moisture vs thickness. Magnetized without dust. A 21 to 23-in. Hg dry vacuum. Filter media: Saran 601.

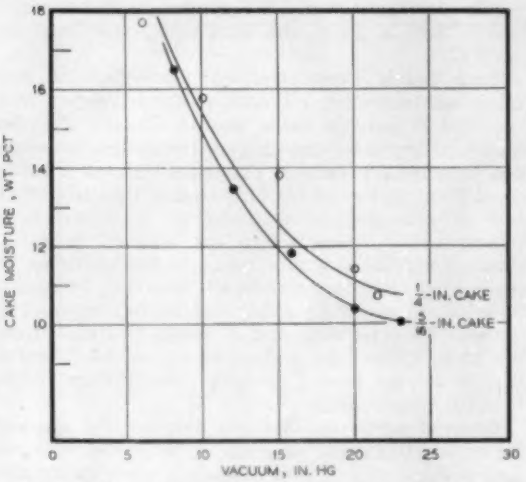

Fig. 4—Cake moisture vs dry vacuum. 1/2-min dry time at 72°F. 81.1 pct —325 mesh at 58 pct solids, magnetized without dust. A 1/4-in. cake at 5-in. Hg form vacuum and 5/16-in. cake at 10-in. Hg form vacuum. Filter media: Saran 601.

is followed by an asymptotic approach to a minimum moisture content. Previous experience has shown that the drying curves for all materials follow this general shape, and it was necessary to plot only a few points to determine the slope and the asymptote for taconite.

Fig. 2 clearly indicates that increased drying times up to 0.6 min lower cake moisture considerably. Once this drying time has been reached, the curve rapidly becomes asymptotic and a very slight decrease in moisture is obtained. As increased drying time decreases the dry solids tonnage rate per square foot from the filter, it is imperative not to extend the drying time longer than necessary. Coarser grinds change the relative position of the curve, but the knee portion of the curve remains identical at about 0.6 min drying time.

Cake Thickness: Decrease in cake thickness causes a decrease in cake moisture. This is due to the increase in total cake permeability as thickness is reduced. Other conditions remaining constant, the specific cake permeability remains fixed. However, the total cake permeability decreases as thickness increases, and the general shape of the moisture-thickness curve for all materials is approximately the same, the cake moisture reducing rapidly to a minimum as thickness decreases. Several tests were made to determine at what thickness this minimum occurred for the taconite concentrate.

The curves in Fig. 3 show that lowest moistures are obtained at cake thicknesses of about ⅜ in. Reduction in thickness beyond this point would not reduce cake moisture significantly and would cause considerable difficulty in discharging the cake from the disk-type filter.

Form Vacuum: Form vacuum is defined as the vacuum applied to the cake-forming or pick-up portion of the filtration cycle. It was established that the highest possible form vacuum should be used to obtain the lowest cake moisture. Test results showed that raising the form vacuum from 10 to 25 in. Hg decreased moisture content more than one percentage point.

Dry Vacuum: The effect of vacuum on the dry portion of the filter cycle is to reduce the moisture content as vacuum or pressure differential is increased. The thin film of liquid on the cake solids is subjected to an increasing air velocity as vacuum increases, reducing liquid film thickness and consequently cake moisture content. Thus the typical moisture-vacuum shows a rapid decrease in moisture to an asymptotic value as vacuum increases.

As shown in Fig. 4, cake moisture becomes asymptotic at about 23 in. Hg. Since cake moisture decreases about three percentage points from 13 to 23-in. Hg vacuum, it would seem essential to operate the filters at or above the 23-in. Hg vacuum level.

Feed Temperature: When feed temperature is increased viscosity is reduced, lowering cake moisture. This reduction in viscosity is more pronounced at lower temperatures. For example, a viscosity change from 32° to 50°F is 0.5 centipoise for water, but from 50° to 70°F it is only 0.3 centipoise. From this it can be expected that cake moisture will decrease rapidly when the feed temperature is raised from 32° to 50°F and will decrease more slowly with further temperature increases. A similar phenomenon has been noted in dewatering coal at wet processing plants.[1]

The curve in Fig. 5 follows expectations and eventually becomes asymptotic as temperature increases. It will be noted that the lowest cake moisture is obtained after feed temperature has reached 80° to 90°F and that moisture increases very markedly if feed temperature is reduced beyond 50°F. Feed temperature should be kept as far above 50°F as is practical under plant conditions by limiting the use of fresh water make-up in the circuit.

Percent —325 Mesh Solids in Feed: Fig. 6, a graph of the moisture-grind relationship, shows the rapid increase in cake moisture as the grind increases past 90 pct —325 mesh solids. This is due to a decrease in porosity and permeability of the cake and to an increase in the specific surface of the solids. Between 70 and 90 pct —325 mesh the curve is not as steep as beyond 90 pct, but cake moisture content continues to decrease steadily with coarser grind.

Feed grind is determined by plant operation in recovery of iron from ore and cannot be lowered appreciably to reduce cake moisture content. Test results show, with regard to cake moisture, that there will be considerable difficulty in the balling and pelletizing operations as feed grinds increase beyond 90 pct —325 mesh. For best operation it is

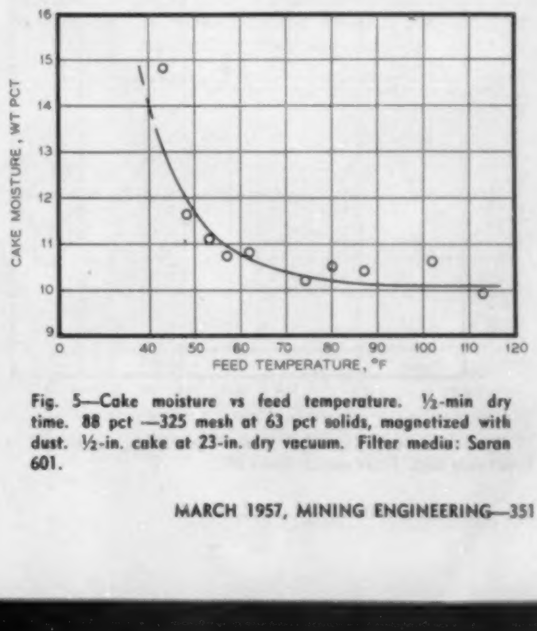

Fig. 5—Cake moisture vs feed temperature. ½-min dry time. 88 pct —325 mesh at 63 pct solids, magnetized with dust. ½-in. cake at 23-in. dry vacuum. Filter media: Saran 601.

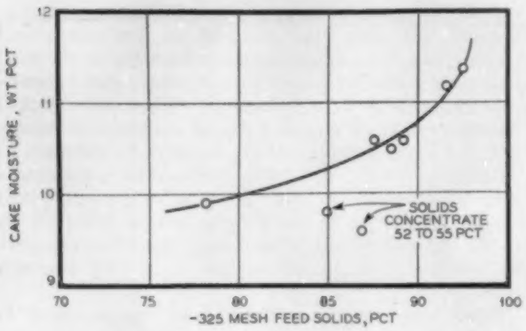

Fig. 6—Cake moisture vs percent —325 mesh. A ½-in. cake at 22 to 23-in. Hg dry vacuum. ½-min dry time at 70°F. 60 pct solids, magnetic without dust. Filter media: Saran 601.

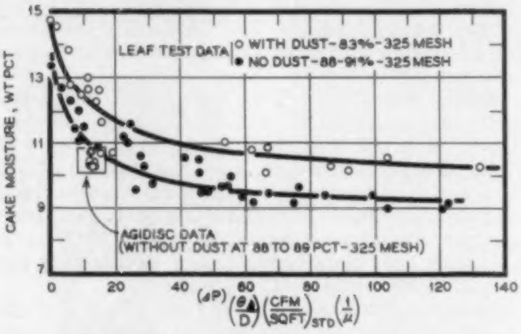

Fig. 7—Cake moisture vs general correlating factor. Comparison of Agidisc data (run without dust at 88 to 89 pct —325 mesh) with leaf test data. Filter media: Saran 601.

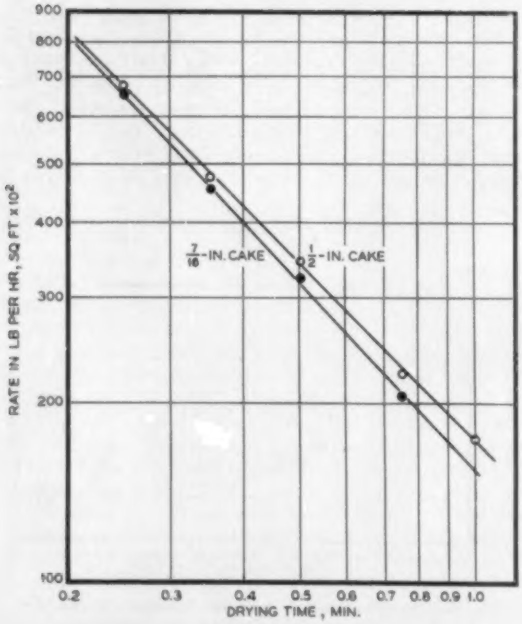

Fig. 8—Rate vs drying time. 57 to 59 pct solids, magnetized without dust. Filter media: Saran 601.

highly desirable that a minimum grind be maintained that is consistent with acceptable iron recovery.

Feed Solids Concentration: The effect of feed solids concentration on cake moisture varies with the type of material being filtered. Usually the cake moisture decreases as solids concentration increases, but occasionally certain materials exhibit a minimum point in the curve. This relationship is a function of cake formation. Different materials form tighter cakes according to the amount of solids present and the size and shape of the particles. In the case of taconite concentrate filtration, the minimum in the moisture-solids relationship appears to be near 55 pct solids, and it seems probable from the data that cake moistures could be lowered slightly by decreasing the pulp density from 70 pct towards 55 pct solids.

Effect of Additives: With the discovery of new and better additives and reagents, some industries have incorporated their use to produce a more easily discharged and/or a more easily handled cake. It was hoped that certain of these additives could be used to lower the moisture content of the filter cake, since ease of handling is already at optimum level.

Two additives that were believed to have the greatest chance of success are Separan, which is a flocculant, and Tween 81, a non-ionic wetting agent. Separan actually increased the cake moisture content and was discarded in further testing. When Tween 81 was used, moistures were slightly lower until after 0.75 drying time, when they became greater than without the additive. It was decided that the slight reduction in moisture did not warrant the expense of using this additive.

Effect of Various Cloths: A number of cloths were tested in comparison with a monofilament Saran cloth with a 6/1 Satin weave that has been used very successfully on filters at the Babbitt plant. It was hoped that a cloth would be found that would produce a cake with lower moisture content while permitting the good discharge obtained with Saran cloth.

The cloths tested were monofilament nylon, monofilament Polyethylene, monofilament Saran, and high-twist multifilament nylon. All gave cake moistures and discharging properties similar to those attained with the Saran cloth already employed. It is possible, however, that these cloths would last longer than the Saran.

General Correlation: To present an overall picture in one graph, cake moisture was plotted as a function of a general correlating factor incorporating all major filter operating variables directly affecting moisture. These factors are pressure drop (vacuum level), drying time, cake thickness, air rate through the cake, and viscosity (temperature). The correlating factor is as follows:

$$\text{Correlating factor} = (\Delta P)\left(\frac{\theta_D}{D}\right)\left(\frac{\text{cfm}}{\text{ft}^2}\right)_{std}\left(\frac{1}{\mu}\right)$$

in which ΔP = pressure differential or the vacuum level on the drying portion of the filtration cycle, expressed in inches of mercury vacuum.

θ_D = drying time (that portion of the filtration cycle in which the cake under

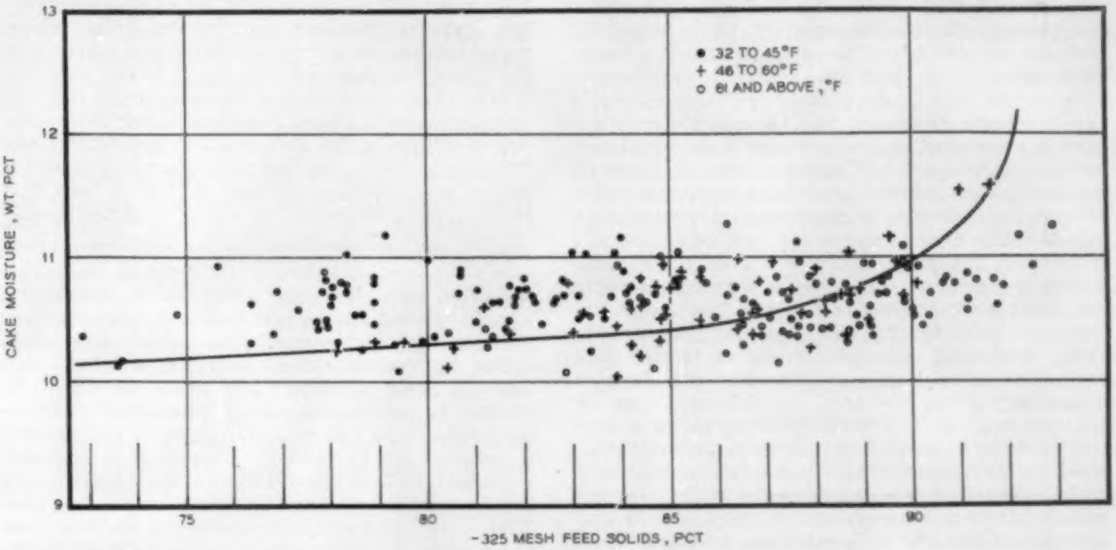

Fig. 9—Cake moisture vs percent —325 mesh. Operating data from Agidisc filter at Babbitt, Minn., January through September 1955. Water temperatures: 32° to 45°F, 46° to 60°F, and 61°F and higher. See corresponding symbols above.

vacuum is exposed to the atmosphere) expressed in minutes.

D = cake thickness expressed in inches.

$\left(\frac{\text{cfm}}{\text{ft}^2}\right)_{std}$ = air rate through the cake during the dry cycle expressed in cubic feet of gas per minute per square foot of filter area at standard conditions (atmospheric pressure and 60°F).

μ = viscosity of the liquid passing through the cake solids expressed in centipoises.

This general correlation has been developed previously and will be found in the technical literature.[1-6] For any individual series of tests the filter media, feed solids concentration, dust content, and grind were held fixed. However, the feed grind or feed solids size distribution should be considered a major parameter in any correlation of moisture content as a function of this factor. Since the return dust content of the filter feed affects the feed solids size distribution, the return dust content is actually a parameter similar to feed grind.

The top curve in Fig. 7 represents data taken at Babbitt with dust, and the lower curve illustrates results without return dust present. It will be observed that cake moisture decreases rapidly at first as the correlating factor increases. Then moisture slowly decreases to an asymptotic value upon further correlating factor increases. This graph has an expanded moisture scale to allow the points to be read more easily. Ordinarily, plotted moisture values are closer together and this curve would exhibit a very sharp break to an asymptotic line. Actually the correlation curve of taconite concentrate shows one of the sharpest breaks of all materials tested. This means that the taconite filter cake reduces to its asymptotic value much more rapidly than most materials. From the standpoint of economical design, operating conditions would be the highest point on the curve that gave the desired moisture for pelletizing. However, if any fluctuations in operating conditions occur, there is a strong danger that moisture content will be too high, if the value of the correlating factor is lowered. Optimum operation would be closer to the base or in the relatively flat portion of the curve. At this point approximately the lowest moistures obtainable will be realized. If sudden upsets or peak tonnages arise and operating variables cause the correlating factor to decrease, cake moisture will increase only slightly, causing no hindrance to following operations.

Curves in Fig. 7 indicate that size distribution of feed particles greatly affects the cake moisture. It is also evident that the addition of return dust (with its excess fines and slime content) changes the feed size distribution sufficiently to cause a drastic change in cake moisture.

Normal operation at the Babbitt plant with the present tonnage and filtration equipment would produce a correlating factor of 10 to 20. For this range the average moisture content would be 11.0 to 10.5 wt pct. To obtain an optimum position for ease of operation and lower cake moistures, it will be necessary to increase the correlating factor to a more level position on the curve. This means that the variables incorporated in the correlating factor must be changed: 1) Pressure differential is now at maxi-

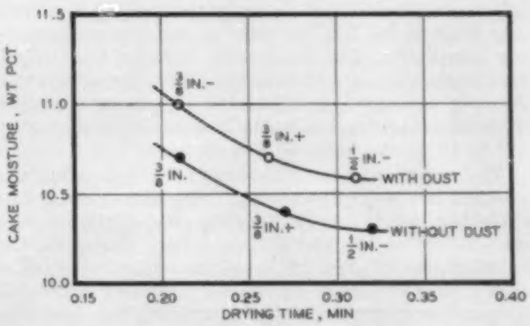

Fig. 10—Agidisc filter: cake moisture vs drying time. 85 to 86 pct —325 mesh at 55 to 57 pct solids, magnetic feed. 23 to 24-in. Hg dry vacuum at 59 to 60°F. Filter media: Saran 601.

mum value, which was found to be the most economical position. 2) Drying time can be increased to increase the correlating factor and result in a lower cake moisture. 3) Cake thickness is approximately at its lowest limit in the present operation and cannot be greatly improved. 4) Air rate through the cake is dependent on the pressure differential and vacuum pump used and therefore remains fixed at the particular quantity associated with maximum vacuum. 5) Viscosity is dependent on temperature of feed to the filters. Since it may not be economical to increase this temperature, which cannot be controlled appreciably, the viscosity factor is more or less fixed with the time of year. The remaining variables, pulp density and pulp grind, are not directly associated with the correlating factor—they are a function of plant operation and therefore fixed quantities. Thus the only variable that can be changed to obtain a larger correlating factor is drying time. If all remaining variables are held constant at optimum or operational levels, drying time can be increased to obtain lower moistures and greater stability of operation. As drying time also affects the capacity or production of the filter, a change in this factor influences the economics of the operation.

Rate: Rate varies inversely with cycle time in all installations. According to the ideal relationship, rate is a function of time to the $-\frac{1}{2}$ power. In this case, however, it was decided to increase drying time alone and hold cake thickness constant. A log-log plot of rate vs drying time with constant cake thickness results in a straight line with a slope of -1. This is illustrated in Fig. 8.

Expected plant operation will use a drying time of 0.25 to 0.35 min. With a cake of 7/16 in., this results in a rate of about 550 lb dry solids per hr per ft². If the operation were changed to permit a longer drying time, the rate would drop in accordance with Fig. 8 if the cake thickness were held constant at 7/16 in. The conclusion reached from analysis of Fig. 2 (moisture vs drying time) was that prolonged drying time up to 0.6 min was advantageous. The rate at 0.6 min drying time with 7/16 min cake thickness would be about 265 lb per hr per ft² (Fig. 8). Productive capacity of the filter would be halved with this increase in drying time. The effect on cake moisture is evident in Fig. 7. With the doubled drying time, the correlation factor is doubled to the 20 to 40 range, with a reduction of 0.5 pct cake moisture.

Agidisc Filter Results

To correlate the previous leaf test analyses with full-scale results, tests were performed on the Agidisc filter at the Babbitt plant under typical operating conditions. Fig. 9 presents data on feed grind, feed temperature, and cake moisture, compiled from January through September 1955. Data were classed in three groups according to feed temperatures from 32° to 46°F, 46° to 60°F, and above 60°F.

The curve in Fig. 9 was drawn through what was selected as the median temperature range. All points falling in the 46° to 60°F group were placed in this median range. It will be noted that almost all the points in the 32° to 45°F range are above this median curve, whereas most of the points above 60°F fall below the curve. This substantiates the leaf test temperature results illustrated in Fig. 5. It is also interesting to note that almost all the 32° to 45°F data lie between 76 and 85 pct −325 mesh, whereas data above 60°F lie primarily between 83 to 93 pct −325 mesh. This can be partially explained by the fact that the classifiers used in the circuit would naturally operate at lower classification points with the higher temperatures due to the lower viscosity.

This same curve verifies the pulp grind leaf test data presented in Fig. 6. If reduced to the same scale, both curves have the same slope at identical grinds. The data curve for the leaf tests is lower in position, having been obtained on feed without return dust present. Most of the data in Fig. 9* included dust in the filter feed. The only difference in the curves, therefore, would be the difference in cake moisture obtained with and without return dust in the feed.

One conclusion reached from the leaf tests was that the only variable that could presently be changed to reduce cake moisture at Babbitt was drying time. To do this on a plant filter it is necessary to increase the cycle time. This in turn increases form time, resulting in a thicker cake. As mentioned before, thicker cakes produce higher cake moisture. Even with increased cake thickness, however, the decrease in moisture upon prolonged drying is apparent (Fig. 10). If cake thickness were held constant the moisture decrease would be greater with increased drying time, as shown in Fig. 2. In Fig. 10 a comparison is made between feed with and without dust. Throughout the range tested the difference between results is about 0.3 pct moisture. Thus the relationship between cake moisture and drying time as shown by the leaf tests is verified by results from the Agidisc filter.

As no one variable could be separated during the full-scale filter studies, the only effective way to compare the leaf test results with the plant filter results would be to use the correlating factor in evaluating the data, exclusive of size distribution. It then makes no difference during the tests whether one variable or all variables change—the factor incorporates alterations into one total change.

The curve representing the leaf test results of feed without dust was used as a basis of comparison with data obtained on the Agidisc filter of feed without dust. Results for the Agidisc filter (shown on lower curve of Fig. 7) lie almost on the curve for the leaf tests. Their moisture values are slightly lower than the leaf test values at the same correlating factor. However, the leaf test data were obtained on feeds of 88 to 91 pct −325 mesh, whereas the Agidisc results were obtained on feeds of 86 to 89 pct −325 mesh. It would be expected, therefore, that the feeds with the coarser grind would have slightly lower cake moistures, as pointed out previously. Allowing for this difference in pulp grind, values for both leaf and Agidisc tests would be similar. It is safe to conclude that results reached from leaf test work can be applied to large filter operation.

Conclusions

Based on results obtained with the leaf tests and later confirmed on the Agidisc filter at Babbitt, the following conclusions are made with regard to minimizing cake moisture:

1) Cake moisture can be lowered by prolonged drying time. Drying times longer than 0.6 min are probably not economical. A drying time of 0.6 min would decrease moisture content at Babbitt by 0.5 to 1.0 pct under present operating conditions.

Present operation: 0.25 to 0.32 min drying time

* Taken from daily averages incorporating results from all hours of the day.

2) Filtration rates at Babbitt are now 550 lb per hr per ft². Increasing the drying time to 0.6 min would drop filtration rate to 275 lb per hr per ft², but with a decrease of 0.5 pct or greater in moisture content.

Present operation: 550 lb per hr per ft²

3) Cake thickness should be as thin as possible and still maintain good discharge ability. This is about ⅜ in.

Present operation: ⅜ to ½ in.

4) Both form and dry vacuum levels should be as high as possible to obtain the lowest cake moisture content. This level determines the air rate through the cake for a particular vacuum pump.

Present operation: top vacuum

5) Lower cake moistures will be obtained with increased feed temperatures. If possible, feed temperatures should not fall below 50°F.

Present operation: function of climatic conditions only

6) Increased pulp grind increases cake moisture content. Grind should be maintained at a minimum −325 mesh percent consistent with acceptable iron recovery. However, if 90 pct −325 mesh or greater must be employed, cake moisture will rise appreciably.

Present operation: normally about 88 pct −325 mesh

7) Optimum pulp density for the Agidisc filter is not known precisely but the operation appears good at 55 to 60 pct solids.

Present operation: 55 to 65 pct

8) The filter medium that should be used is Eimco Saran 601 until a medium with better overall performance is discovered. Cloths that might prove better from an economic standpoint are nonfilament nylons and Polyethylenes and high twist nylon.

Present operation: Eimco Saran 601

9) Addition of normal amounts of return dust of the filter feed at Babbitt increases cake moisture about 0.3 pct over feed without dust.

Present operation: with dust

Acknowledgment

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Experiments in Induced Polarization

by John H. Henkel and Robert G. Van Nostrand

TRANSIENT potentials obtained in resistivity prospecting can be separated into two classes. The first is electromagnetic, has a comparatively short time constant, and increases in relative amplitude as the electrode separation is increased. These electromagnetic transient potentials, of which an excellent theoretical treatment is given by Yost,[1] are the result of changes in the current and can be classed as *differentiated* signals. The second class is electrochemical, has a comparatively long time constant, and decreases in relative amplitude as the electrode separation is increased. The electrochemical signals are generated by the current flow itself and can be classed as *integrated signals*. The transient potentials due to electrochemical factors are the subject of this article. The phenomenon is referred to as *induced polarization*.

Schlumberger[2] was the first worker to observe induced polarization, but he was unsuccessful in attempts to apply the principles of induced polarization in electrochemical prospecting. Other workers, notably Bleil,[3] have studied polarization and in some cases pointed out its possibilities, but no theory has been presented that describes polarization and its time dependence adequately. It is the purpose of this discussion to present the essence of a theory to geophysicists and to show that it leads to results consistent with experimental evidence. The theory on which this analysis is based has existed in electrochemical circles since 1910.[4]

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Three assumptions underlie this theory. Following the work of Hittorf,[5] it is assumed that there is no net free charge at any point in the solution, even though the conduction is electrolytic in nature.* It can be seen that this is true when current flows through a long tube, with copper electrodes at each end, containing an electrolyte such as a solution of $CuSO_4$. If the fraction of the total current carried by the copper ions is designated by α, the fraction of the total current carried by the sulfate ions is given by $1-\alpha$. After a passage of I amperes for a short time, Δt, a total of $(\alpha I \Delta t)\left(\frac{N}{2F}\right)$ copper atoms have moved away from the anode. In this expression, N is Avogardo's number, F is one Faraday of electric charge, and 2 is the valence of the copper. During the same interval of time, a total of $(I\Delta t)\left(\frac{N}{2F}\right)$ atoms of copper enter the solution according to Faraday's law. Therefore the region immediately adjacent to the anode is enriched in copper by $(1-\alpha)(I\Delta t)\left(\frac{N}{2F}\right)$ atoms during the interval Δt. Also during the same interval of time, the same number of sulfate ions enter the region adjacent to the anode. However, a complex reaction takes place at the anode: oxygen is liberated and the sulfate ions are held in solution, thus enriching the anodic region by a number of sulfate ions equal to the excess of copper ions. A similar analysis shows that the region adjacent to the cathode loses the same number of copper sulfate molecules that the anodic region gains.

The second assumption follows from the first and states simply that the polarization potential observed in electrical prospecting is a concentration potential.* Although the principal electrolyte in the earth is sodium chloride solution, its behavior would follow that given in the above example. Therefore, a concentration cell is established between the regions around the cathode and anode. When the energizing current is stopped, it is possible to observe an *induced polarization* current as this concentration cell dissipates its stored energy.

* This is open to objections, since it is assumed that the induced polarization occurs at the surfaces of clay particles where there is a space charge whose distribution falls off exponentially from the surface of clay particles, as calculated by using Boltzmann's distribution.

* This assumption is open to criticism, since Agar and Bowden[6] point out other types of polarization.

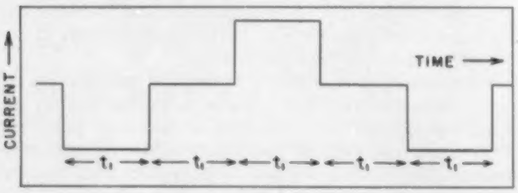

Fig. 1—Typical current shape used in polarization experiments.

The third assumption ties the laboratory model to field experience. The authors believe that earth materials, and particularly clays, are selective in the transmission of ions. Although there is disagreement as to the actual mechanism involved,[7,8] it appears that certain clay particles permit only the passage of positive ions in a manner analogous to that by which metals permit only the passage of electrons, provided the concentration of the solute is small compared with the space charge of the clay particles. Therefore each face of one of these clay particles in an electric current becomes an electrode which furnishes a region of anomalous concentration as described above. After an energizing current has been terminated, each of these elementary concentration cells discharges, adding to the net effect that is measured at the surface of the earth.

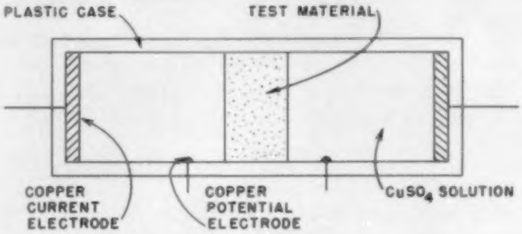

Fig. 2—Test cell for polarization experiments.

In the interest of simplicity, only the basic equations are presented, without discussion as to how they are solved. Details will be found in the article by Rosebrugh and Miller,[4] on whose work this development is based.

As originally derived and as presented here, this theory is strictly applicable only to metal electrodes in contact with homogeneous electrolytes. However, it will be seen later that the theory gives satisfactory agreement with experimental data obtained in porous media where the assumed conditions are questionable. The authors believe it to be at least a good approximation in porous earth materials.

First, the current density due to migration of ions arising both from differences in concentration and an impressed electric field is

$$\overline{J^{\pm}} = F Z^{\pm} (\pm D^{\pm} \nabla C^{\pm} + M^{\pm} C^{\pm} \overline{E}) \qquad [1]$$

Here Z is the valence without regard to sign, F is 62,500 coulombs, D is the diffusion constant, C the concentration, M the ion mobility, and $\overline{E}$ the electric field. The plus and minus signs used as superscripts refer to the positive and negative ions respectively. The basic equation to be solved is the equation of continuity:

$$\nabla \cdot \overline{J^{\pm}} = \mp Z^{\pm} F \frac{\partial C^{\pm}}{\partial t} \qquad [2]$$

Its solution is subject to Laplace's equation:

$$\nabla \cdot \overline{E} = 0 \qquad [3]$$

The applicability of Laplace's equation arises from the fact that the net charge is everywhere zero in the solution, except perhaps within a distance of a few molecular diameters of the metal surfaces. The diffusion constant can be expressed in terms of the ionic mobilities by the following relationship:

$$D^{\pm} = \frac{M^{\pm} R T}{Z^{\pm} F} \qquad [4]$$

where R is the universal gas constant and T is the absolute temperature.

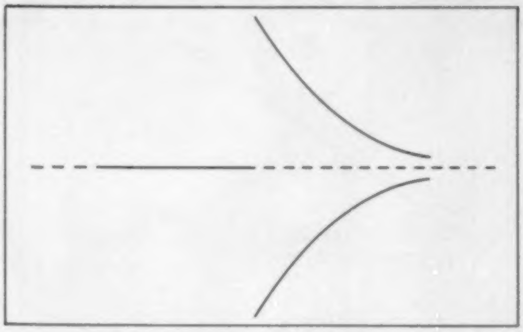

Fig. 3—Typical oscillograph display of polarization signals.

Because there seems to be little hope of determining the many complex constants that enter the polarization equations as applied to earth materials, examination of the time dependence of the solutions discussed by Rosebrugh and Miller offers the most convenient check on validity of the theory. Moreover, the time dependence is the same whether the problem to be considered is one-dimensional or three-dimensional.

For sufficiently small current densities, such as are used in electrical prospecting, it is found that the polarization electric field due to a single current pulse is given approximately by

$$E = K\,f\,(x,y,z)\sum_{n=1}^{\infty}\frac{1}{(2n-1)^2}\left[e^{-(2n-1)^2kt}-e^{-(2n-1)^2k(t+t_1)}\right] \qquad [5]$$

The constants K and k depend on the geometry of the experiment, as well as the electrical properties of the solutions involved, and $f(x,y,z)$ is a function of position. Also, it will be noted that K is a linear function of the total current I. The time t is measured from the instant the energizing current is turned off and t_1 designates the time the energizing current is applied to the ground or to a given sample. Thus it is seen that the first term in brackets arises from the end of the current pulse and the second term arises from the beginning of the current pulse.

If the energizing current is applied and measurements are made in a repetitive fashion, there will be a set of terms in the solution corresponding to the two given above for every interval during which the current is applied. Consider the case in which the energizing current is applied as shown in Fig. 1:

$$E = K\,f(x,y,z)\sum_{n=1}^{\infty}\sum_{m=0}^{\infty}\frac{(-1)^m}{(2n-1)^2}\left[e^{-k(2n-1)^2[t+2mt_1]}-e^{-k(2n-1)^2[t+(2m+1)t_1]}\right] \qquad [6]$$

where t is now measured from the last time the current is turned off.

Experimental Procedure: Fig. 2 shows the specially designed cells in which the laboratory experiments were performed. These cells consisted of rectangular boxes 4 in. long and 1½ in. square. Each end of the box was covered with a copper electrode through which current was brought into the cell. Since these electrodes covered the entire cross section of the cell, the current flow was considered to be one-dimensional. In some cases the open top of the cell was covered with wax to eliminate evaporation and thus to maintain homogeneity.

The electrolyte was usually copper sulfate solution in various concentrations, although other salts including sodium chloride were sometimes used with comparable results. Nonpolarizing potential electrodes were tried but gave the same results as the copper electrodes, which were more convenient to use.

Although $CuSO_4$ is not the salt that enters into most reactions in the earth, the authors believe that the same principles are involved regardless of the salts used. $CuSO_4$ was used because it was believed that there was some improvement in the performance of the potential electrodes when the copper was in contact with a salt of copper.

The test substances were cut into plates, which exactly filled the cross section of the cell, and were placed in the center of the cell. These samples consisted of metal plates singly or in combination, sandstones, shales, and limestones. For certain experiments, loose sand samples were used; in this case, the sample filled the whole cell and the conducting fluid filled only the pore spaces in the sand. The potential differences across the sample were measured through the two small copper electrodes placed as shown in Fig. 3. It was considered that these electrodes were small enough not to upset the conditions being measured or the linear flow of current that was assumed.

In all cases the current was applied to the cell in the manner illustrated in Fig. 1. The reversing feature of the current was chosen so that a cumulative polarization would not be produced. The sweep of the oscilloscope on which the transient potentials were observed was adjusted so that the signal for negative current was superimposed on the signal for positive current (Fig. 3). By working with the difference between these two signals, it was possible to eliminate the effect of any natural potential difference between the potential electrodes. During normal operation the potential electrodes were disconnected while current was being applied to the cell. The reason was that the in-phase potential is comparatively so large that accurate measurement of the polarization potential would be difficult if the two were recorded on the same scale. Signals similar to those shown in Fig. 3 were recorded by photographing the traces on the oscilloscope screen.

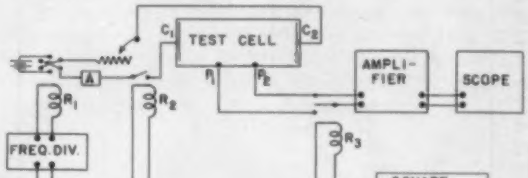

Fig. 4—Schematic diagram of apparatus used to measure induced polarization.

Fig. 4 is a diagram of the circuit used to study polarization. All the switching was done with mercury contact relays. The output of a square wave generator regulated relays R_2 and R_3. It also regulated the frequency divider, which in turn controlled the relay R_1. The relay R_1 makes and breaks the current switch, thus generating a train of square

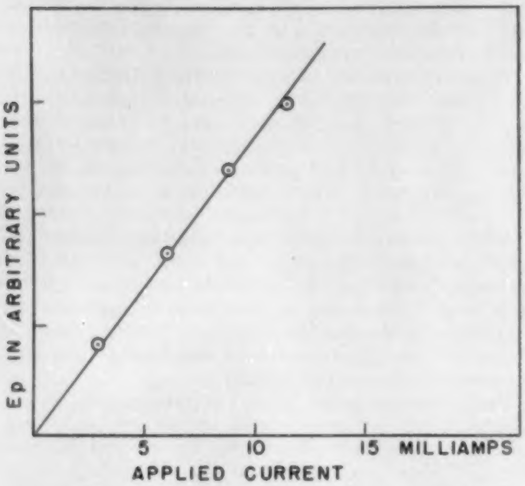

Fig. 5—Relationship between polarization and energizing current.

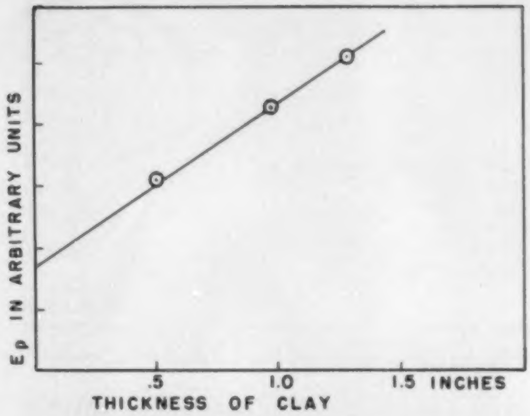

Fig. 7—Effect of clay thickness on polarization.

pulses of much larger amplitude than could be obtained directly from the square wave generator. The relay R_1 reverses the polarity of the current line every time the current switch goes into the off position. The bi-directional square wave shown in Fig. 1 was produced with this device. The relay R_2 shunts the amplifier while the energizing current is flowing and connects the potential electrodes to the amplifier 1 m-sec after the current is turned off. This delay eliminates the electromagnetic transients from the record. In most of the experiments the currents used were of the order of a few milliamperes or smaller.

Results: In most of this work, the index used to measure polarization was the peak-to-peak signal. *Peak-to-peak polarization* is the maximum difference between the positive and negative signals. Because of the manner in which the measurements were made, this maximum occurred 1 m-sec after the current was turned off. This quantity is designated as E_p.

The result when there was no sample in the cell is as important as later results obtained with samples. The cell was filled with various electrolytes in a variety of concentrations. With no solid obstructions between the potential electrodes in the cell, no polarization signal could be detected. This kind of experiment satisfied the writers that they were not measuring electrode effects in later experiments.

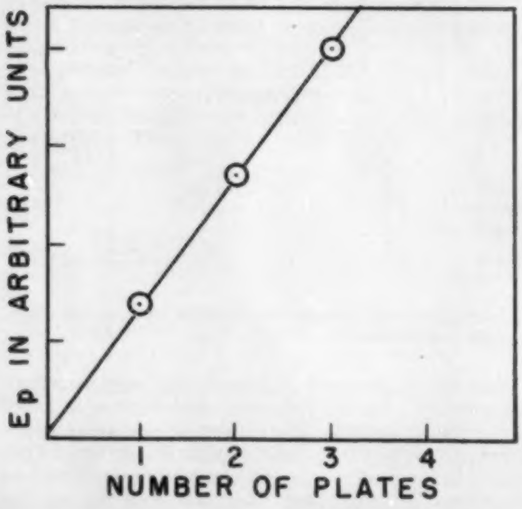

Fig. 6—Effect of the number of surfaces on polarization.

The theory shows that for low current density the polarization potential should vary directly as the current density. If the geometry of the experiment is not changed, the current density varies directly as the total applied current, which is the quantity used in the comparison. This dependence is illustrated in Fig. 5, in which the peak-to-peak polarization is plotted against the current applied to the cell. The experiment was run with a copper plate placed between the potential electrodes so that the entire current passed through the plate. For currents up to 10 ma, it was found that the polarization is proportional to the applied current. The corresponding current densities in the cell were larger than those used in electrical prospecting except in the immediate vicinity of the current electrodes. For larger currents, it was found that the ratio E_p/I decreased slightly, but the writers did not reach what they could consider to be saturation.

The number of copper plates between the potential electrodes was varied to show that the phenomenon under investigation is a surface effect. Results are shown in Fig. 6. The plates used were cleaned with nitric acid, and every effort was made to make them identical. When a single plate was used, the results were independent of the thickness of the plate. It can be seen from Fig. 6 that the polarization varied linearly with the number of plates (or surfaces) introduced between the potential electrodes.

An analogous experiment was performed on clay to show that the effect in clay is a bulk property of the clay itself and not a function of its visible, external surfaces. Fig. 7 shows the result of increasing the thickness of a sample of clay. The polarization due to clay varies directly with the thickness of the sample.* In this case, large potential electrodes were used to hold in place the samples that were actually a viscous drilling mud. It was the effect of these electrodes that caused the *zero-thickness* potential observable in Fig. 7.

The writers also checked the dependence of polarization on concentration of the electrolyte. Fig. 8

* In connection with the work on clays it is well to mention the work of Vacquier.[9]

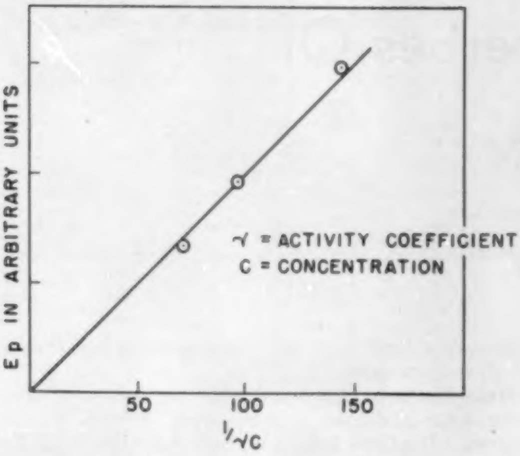

Fig. 8—Relationship between polarization and the electrolytic concentration.

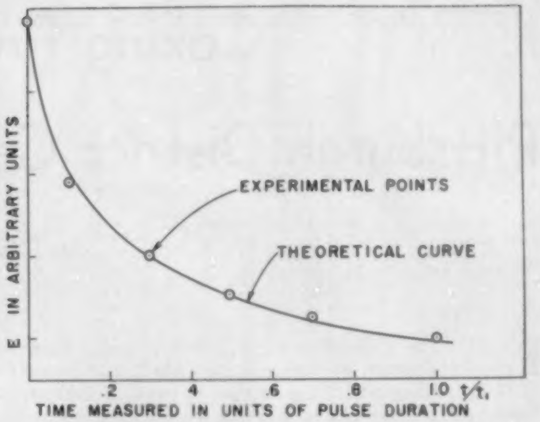

Fig. 9—Typical decay of polarization with time.

shows a plot of the peak-to-peak polarization as a function of $1/\gamma C$ where γ is the activity coefficient of the copper sulfate solution at concentration C. The activity coefficients used are those given by Taylor.[10] As predicted from the theory, these points all fall on a straight line.

The most important test of the theory is the dependence of the polarization decay upon time. Fig. 9 shows some experimental data (plotted points) and a theoretical curve (solid line) that was calculated from the time dependence indicated above and adjusted arbitrarily to an appropriate scale. Although the data shown are for an experiment in which a copper plate was used, they are typical of all the data both for copper plates and for earth materials. It is believed that the excellent agreement shown here enhances considerably the value of the theory outlined in this article. The authors have fitted equally well many of the field curves Van Nostrand and Farnham[11] obtained in Virginia using the Wenner configuration on the surface of the ground.

In addition to the work discussed, the writers have performed many other miscellaneous experiments. For example, they have found that clean sand does not display polarization but that small amounts of impurities, such as are found in naturally occurring sands, cause marked polarization. Limestones display polarization that varies considerably from sample to sample. They have also found that polarization of a metal plate depends largely on the nature of its surface. A clean plate does not polarize nearly as much as one that is covered with natural corrosion. This point has not been stressed here because its geological implications are not at all obvious.

Conclusions

From the experiments described, it is concluded that induced polarization is a surface phenomenon and is present whenever the mode of electrical conduction changes. Polarization occurs, for example, whenever electrical conduction changes from electrolytic to metallic or whenever the transference numbers of the participating ions change as they do at a liquid-liquid contact. Clay particles are of prime importance in polarization in the earth because they tend to obstruct the passage of anions.

Experiments, as far as they have gone, verified the theory. It was shown that the time dependence of the phenomenon was as described by Eq. 6; it was proved that for sufficiently small current densities the polarization is proportional to the applied current; and it has been shown that the polarization is inversely proportional to the chemical activity times the concentration of the electrolyte. Although the writers have not thoroughly investigated the cause of induced polarization, they believe that the facts reported here are pertinent to an understanding of induced polarization. Such understanding is essential to the eventual exploitation of induced polarization in geophysical prospecting.

Acknowledgments

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Coking Properties Of Pittsburgh District Coals

by F. W. Smith, D. A. Reynolds, and D. E. Wolfson

IN 1948 the U. S. Bureau of Mines began a three-phase program to evaluate the extent and quality of U. S. coking coal: 1) a factual appraisal of known recoverable reserves in beds of mineable thickness, 2) a study of preparation characteristics, and 3) a study of carbonization properties. A previous paper presented the methods used in assessing reserves.[1] Although this investigation is only partly completed, data on coking properties of the Pittsburgh district coals are now available. The results are presented in this article.

When coals are selected for manufacture of metallurgical coke more factors must be considered than for any other major use, as no basic industry requires coal of such high quality and uniformity. This is particularly true in the Pittsburgh district, where blast furnace practice is based on use of cokes from high quality coals. Although it is true that inferior coals are carbonized in other industrial areas, both here and abroad, the Pittsburgh coals are the best economically obtainable in the required tonnages, even though they are not the most desirable for metallurgical use.

In the general evaluation of suitability of coals for coke making, particular attention is given to: 1) reserve, 2) ash and sulfur content, 3) inherent properties of forming strong, well fused coke, 4) expanding characteristics, and 5) blending properties. Items 1 and 2 are covered in detail in the first two phases of the survey, and coking behavior is considered in items 3 through 5.

Problems in Coal Evaluation: Although not all coal beds of immediate or potential use to the coking industry in the Pittsburgh area have been tested for their coking properties, enough tests have been made to permit certain generalized statements. Virtually all the coals that will be used in this district are from the Appalachian region, and except for high oxygen coals from outcrops or stripping operations, they are coking coals. Hence the evaluation problem is not so much that of distinguishing between coking and noncoking coals as attempting to measure quantitatively differences in the coking and expanding properties of the better coking coals. Quantitative differentiation between good coking coals is complex, since differences in their coking abilities are frequently of about the same magnitude as the precision of the test. Small-scale tests are generally unsuitable for measuring these slight differences, and there has been gradual acceptance of pilot-scale tests.

Test Methods Employed: All the data reported here were obtained in two units known as the Bureau of Mines-American Gas Association (BM-AGA) carbonization apparatus and the sole-heated expansion oven. The BM-AGA unit, which consists essentially of a cylindrical steel retort about 18 in. diam and 26 in. high, carbonizes enough coal (180 lb) to allow evaluation of the coke by standard methods of the American Society for Testing Materials. The BM-AGA carbonization procedure and methods of testing the gas, liquid, and solid products have been described.[2]

Expanding characteristics of the coals were determined in the sole-heated expansion oven,[3] wherein the coal charge, heated from the bottom only, is carbonized under a constant applied force and the linear expansion or contraction is measured. Although results in this oven have never been quantitatively correlated with the expansion behavior of coals in conventional slot ovens, they are useful in assessing expansion behavior.

In this report discussion will be confined to results obtained from these pilot-scale units, although the following data are available for most coals: proximate and ultimate analyses, free swelling index, agglutinating value, and plasticity.

Sources of Coals Tested: In selection of coals for coke manufacture, economic considerations are as important as quality, and each coke plant balances these two factors to meet requirements of the most satisfactory coke at lowest price. Although these economic factors may in some instances outbalance small differences in coke quality, they are usually specific to each coke plant and cannot be given in any general statement. Recognizing that coal and plant operating costs are beyond the scope of the survey, the USBM evaluates the coking quality of various coals without regard to their competitive economic status.

For the purpose of this article, coals of interest to the Pittsburgh district are arbitrarily defined as

Table I. Stratigraphic Listing of Pittsburgh and West Virginia Coals

High Volatile	Medium or Low Volatile
Pittsburgh	Bakerstown
Upper Freeport (Thick Freeport)	Upper Freeport
Lower Freeport	Lower Freeport
Lower Kittanning (No. 5 block)	Upper Kittanning
Winifrede (Dorothy)	Lower Kittanning (No. 5 block)
Chilton	Eagle
Cedar Grove (Thacker)	Sewell
Alma	Beckley
Campbells Creek (No. 2 gas)	Fire Creek
Eagle	Pocahontas No. 6
Sewell	Pocahontas No. 4
	Pocahontas No. 3

F. W. SMITH, Chemical Engineer, is Chief, and D. A. REYNOLDS and D. E. WOLFSON are Chemists, Coal Carbonization Section, U. S. Bureau of Mines, Region VIII, Pittsburgh.

TP 4364F. Manuscript, Nov. 22, 1954. AIME-ASME Fuels Conferences, Pittsburgh, October 1954.

Table II. Ranges in Analyses, Coke Strength Indexes, and Expansion of 97 Pennsylvania-West Virginia Coals from 19 Beds

Bed	Number of Samples	Dry, Mineral-Matter-Free Fixed Carbon, Pct	Analysis of Coals*		Coke Indexes**			Expansion†
			Ash, Pct	Sulfur, Pct	Shatter 1½-In.	Tumbler Stability 1-In.	Tumbler Hardness ¼-In.	
(High Volatile Coals)								
Pittsburgh	10	53.3 to 63.6	5.4 to 9.3	0.6 to 4.4	67 to 78	19 to 43	47 to 65	−17.5 to −9.6
Upper Freeport	13	58.7 to 67.7	5.1 to 9.7	0.7 to 3.3	77 to 89	22 to 52	47 to 63	−21.4 to +1.8
Lower Freeport	2	67.4 to 67.7	8.5 to 10.5	1.3 to 2.9	86 to 89	41 to 47	57 to 64	−10.3
Lower Kittanning	7	58.1 to 66.5	5.2 to 9.1	0.8 to 2.7	74 to 81	26 to 40	52 to 59	−31.6 to −10.7
Winifrede	4	62.2 to 63.6	4.1 to 9.9	0.5 to 0.9	74 to 79	22 to 44	54 to 65	−8.3 to −4.4
Chilton	3	62.1 to 63.0	4.3 to 5.7	0.6 to 0.9	66 to 79	40 to 42	59 to 66	−18.9
Cedar Grove‡	5	60.9 to 65.5	3.5 to 5.9	0.6 to 1.5	71 to 81	36 to 49	58 to 64	−14.4 to −4.2
Alma	4	59.1 to 65.9	3.2 to 9.3	0.6 to 1.8	60 to 79	20 to 40	46 to 65	−18.4 to −11.6
No. 2 Gas	5	59.6 to 67.6	2.7 to 12.3	0.7 to 2.7	65 to 86	31 to 46	55 to 61	−31.1 to −5.5
Eagle	3	63.7 to 67.0	5.3 to 7.4	0.7 to 1.4	72 to 77	28 to 52	56 to 68	−15.1 to −2.6
Sewell	2	67.0 to 67.4	4.3 to 5.5	0.6 to 0.6	87 to 90	43 to 54	59 to 66	−0.3 to −7.0
Average§	11	60.9 to 67.6	—	—	68 to 90	32 to 52	58 to 66	−24.3 to 2.2
(Medium and Low Volatile Coals)								
Bakerstown	1	77.1	5.7	1.0	88	59	66	+11.9
Upper Freeport	3	69.5 to 78.6	8.6 to 9.6	0.8 to 1.7	89 to 91	51 to 57	59 to 64	6.5 to 18.6
Lower Freeport	2	73.4 to 74.3	6.4 to 7.2	0.7 to 1.6	89 to 90	57 to 57	62 to 65	16.4 to 21.8
Upper Kittanning	3	73.3 to 79.9	6.0 to 10.9	1.5 to 2.9	87 to 91	53 to 57	61 to 64	6.9 to 17.4
Lower Kittanning	3	69.3 to 77.9	6.7 to 9.1	1.1 to 1.8	87 to 91	48 to 56	59 to 63	2.0 to 13.7
Eagle	5	69.2 to 73.0	5.2 to 8.2	0.8 to 1.5	82 to 88	44 to 53	58 to 69	−20.1 to 17.3
Sewell	7	69.2 to 78.6	2.1 to 7.7	0.5 to 1.1	79 to 96	49 to 59	60 to 66	−11.3 to 26.1
Beckley	4	79.5 to 83.0	3.2 to 8.7	0.4 to 1.1	83 to 93	53 to 58	61 to 65	8.8 to 18.7
Fire Creek	2	76.9 to 79.1	2.4 to 5.2	0.8 to 0.8	88 to 90	51 to 55	60 to 63	2.0 to 21.1
Pocahontas No. 6	2	76.9 to 80.7	5.6 to 13.9	0.6 to 1.0	87 to 91	43 to 49	56 to 62	2.2 to 5.5
Pocahontas No. 4	4	81.2 to 84.2	4.8 to 7.0	0.5 to 1.1	75 to 87	48 to 56	60 to 66	15.2 to 24.7
Pocahontas No. 3	3	81.7 to 82.6	3.3 to 6.5	0.6 to 0.7	81 to 83	46 to 54	61 to 65	14.6 to 22.3

* As carbonized basis.
** Cokes tested by A.S.T.M. methods.
† Expansion measured in sole-heated test oven; results calculated to a bulk density of 55 lb per cu ft with 1 pct moisture.
‡ Upper, Middle, and Lower Cedar Grove beds.
§ Acceptable high volatile Pittsburgh district coals.

those from Pennsylvania and West Virginia. Of the numerous coal beds in these two states, 18 of the more important beds have been selected for discussion. These beds, listed stratigraphically in Table I, are grouped in two general classifications. It is recognized that such a broad classification is not unique and that some overlapping in properties must exist. The Upper and Lower Freeport, Lower Kittanning, and Sewell beds are included in both lists because each has important reserves under each classification.

Coking and Expanding Properties: Table II summarizes ranges in the coking and expanding properties of the more important beds of the Pittsburgh district. Because all tests were made under similar conditions, these carbonization data afford a convenient method of ranking the general coking properties of one coal bed relative to another. However, since there is a marked difference in scale between the BM-AGA unit and industrial ovens, and as quantitative correlations between these units are unavailable, it is difficult to set arbitrary limits within which coals will be suitable for industrial use. As it appeared impossible to obtain quantitative correlation between pilot-scale and full-scale oven tests over the wide range in coke properties obtained in this survey, it was desirable to establish reference values at which laboratory and industrial results could be compared. To furnish these values, 20 high-volatile A coals from all parts of the Appalachian region known to have been coked commercially were tested in the BM-AGA apparatus under the same conditions prevailing in the survey test. Table II presents ranges in test results for the 11 Pennsylvania and West Virginia coals included in this group.

It will be noted that coking properties of the 58 high volatile *A* coals tested in this investigation differed widely. Although low minimum coke-strength indexes were obtained for those beds represented in part by samples containing less than 60 pct dry fixed carbon free of mineral matter, the more typical coals from all beds yielded coke of similar physical properties when compared at the same fixed carbon content.

Most Pittsburgh district high volatile coals yield cokes with strength indexes within the ranges shown for acceptable metallurgical coals of similar rank. Some of the coals rank lower than any of the 11 acceptable coals because they contain less than 60.9 pct* dry, mineral-matter-free fixed carbon, the minimum for the acceptable coals, and it is largely these lower ranking coals that yield relatively weak cokes. With four exceptions, all coals, including those containing less than 60.9 pct fixed carbon, yielded cokes with shatter indexes higher than the minimum (68) for acceptable coals. As measured by the 1-in. tumbler index, coke stabilities of 14 coals were lower than the acceptable minimum (32), but only

* The value 60.9 is not necessarily the lowest limit for all high volatile coals acceptable for metallurgical use; it represents the lowest value for acceptable coals tested by the BM-AGA method.

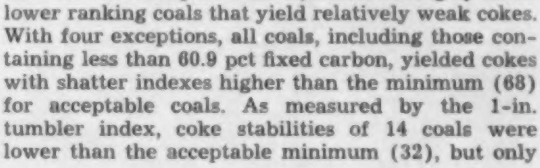

Fig. 1—Effect of coal rank on coke hardness (¼-in. tumbler index) for Pittsburgh district coals.

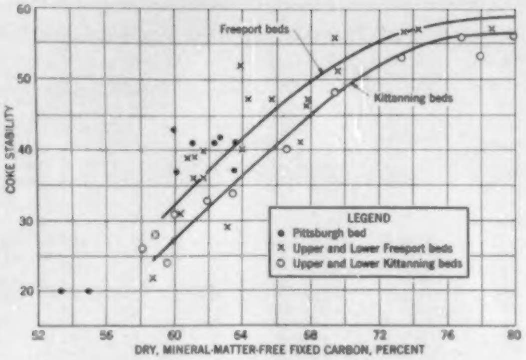

Fig. 2—Effect of coal rank on coke stability (1-in. tumbler index) for Pittsburgh district coals.

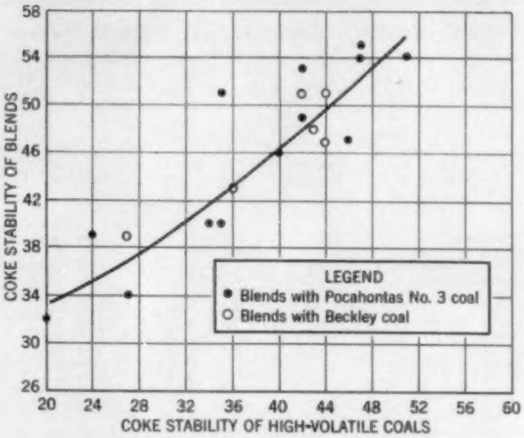

Fig. 3—Effect of blending 20 pct low volatile coal (Pocahontas No. 3 and Beckley) with high volatile coals on coke stability (1-in. tumbler index).

6 of these contained more than 60.9 pct dry, mineral-matter-free fixed carbon. As measured by the ¼-in. tumbler index, the coke hardness of 20 high volatile coals was lower than the acceptable minimum (58); however, 8 of these contained less than 60.9 pct fixed carbon, and 7 other samples contained more than 9 pct ash. It is apparent, therefore, that if they are not high in ash, Pennsylvania and West Virginia high volatile coals containing more than 60.9 pct fixed carbon on the dry, mineral-matter-free basis yield cokes as strong as the average acceptable metallurgical coal of similar rank.

Medium volatile and low volatile coals yield stronger cokes than are obtained from high volatile *A* coals, and Table II shows that the ranges in their coke strength indexes are smaller. Generally the physical properties of coke from single coals of these higher ranks are of minor importance because they expand too much to carbonize safely in modern commercial ovens. Hence they are usually carbonized as blends with contracting high volatile coals. USBM investigations have shown that the blending properties of high rank coals are not closely related to their individual coke-making properties.

Relation of Coking Properties to Coal Rank: From Table II it is apparent that few data are available for most of the coal beds of interest, and even for such beds as the Pittsburgh, Freeport, and Kittanning the samples were obtained from widely separated locations. It is of interest, therefore, to obtain an estimate of the usefulness of available data in predicting the coking properties of coals from areas where actual tests have not been made. Although correlations between carbonizing properties and laboratory-scale analyses have been proposed,[4,5] the data scatter more than can be accounted for by test precision,[6,7] probably because the coking properties depend on geologic factors not adequately described by chemical analyses and rank. USBM work has been directed, therefore, to accumulation of data on given beds for which it is reasonable to assume that the deposition of material and coalification process took place under similar conditions. To date this study is incomplete, but some promising results have been obtained. As shown in Table II, 20 samples of coal from the Freeport beds have been tested, 10 from the Pittsburgh bed, and 10 from the Lower Kittanning (No. 5 block). Data now available for each of these beds are plotted in Figs. 1 and 2. The Freeport coals cover the fixed carbon range 58.7 to 78.6; the Kittanning, 58.1 to 79.9 and the Pittsburgh, 53.3 to 63.6. Apparently the relationship of both coke hardness and stability with fixed carbon for any one series of data is good, and the lines shown afford a reasonable basis for predicting these indexes. Furthermore, the Kittanning coals apparently give slightly weaker cokes than those from the Freeport beds when they are compared at the same fixed carbon content. The average ash content of these Kittanning and Freeport coals (8.5 and 8.1 pct respectively) are too similar to account for the observed differences in coke strength. Although the reasons for these differences are not clear they probably arise from variations in molecular structure caused either by dissimilar species from which the coal substance was formed or by varying chemical action occurring during coalification. Fig. 1 shows that for both the Freeport and Kittanning coals the coke hardness is virtually independent of fixed carbon content in the 60 to 80 pct range. The relative constancy of the hardness index (60 to 65) that has been noted for the vast majority of coals from the Appalachian field indicates that for such coals the ¼-in. tumbler index is not a sensitive measure of the change in coal rank. It is evident that the stability index is more dependent on proximate analysis than is coke hardness. Coke stability is quite dependent on fixed carbon in the range of 60 to 74 pct, becoming less dependent as the rank is increased. Both curves show a plateau effect at the higher ranks, which is in accord with most coal properties.

Figs. 1 and 2 may be used to estimate the coking quality of Freeport and Kittanning seam coals within the range of scatter represented. For about 90 pct of the coals tested, coke hardness can be estimated within ±10 pct of the true value and coke stability within ±15 pct. Although it would be desirable to reduce these ranges, it should be noted that most engineering approximations have about the same margin of error.

The other beds of the Pittsburgh district have not been included in Figs. 1 and 2 because the number of coal samples from each were too limited to establish definite trends. For example, only three samples from the Chilton bed have been tested to date, and these gave ¼-in. tumbler indexes of 59, 60, and 66, at fixed carbon contents of 63.0, 62.6, and 62.1 pct, respectively. The high value of coke hard-

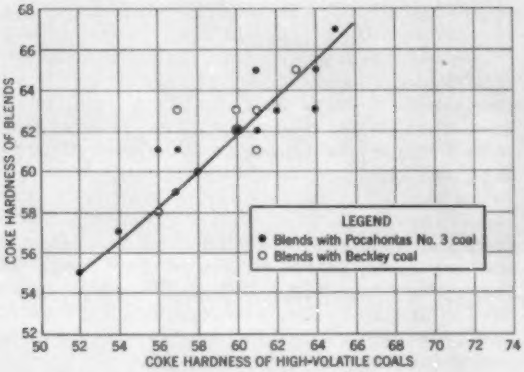

Fig. 4—Effect of blending 20 pct low volatile (Pocahontas No. 3 and Beckley) with high volatile coals on coke hardness (¼-in. tumbler index).

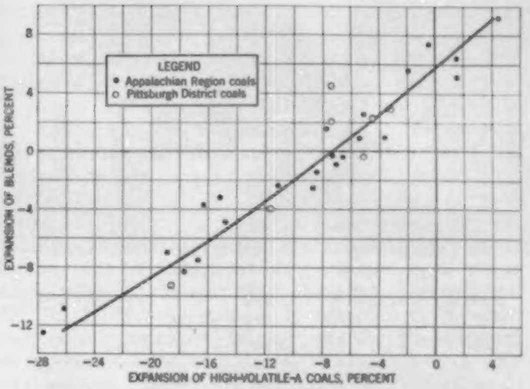

Fig. 5—Effect of blending 20 pct low volatile Pocahontas No. 3 coal with various high volatile coals on coal expansion.

ness was obtained from tests made in the early 1930's on coal from Logan County, W. Va., whereas the other two values were obtained in recent years on samples from Wyoming County, W. Va. At present it is difficult to determine whether these variations are caused by changes in procedure or by basic differences in coking properties of the coals. As more data are obtained by beds over a relatively wide range in coal rank, these differences should be more clearly explained.

Meanwhile an approximation for coals whose coking properties are unknown may be obtained by extending through the available data curves with the same general shape as those shown in Figs. 1 and 2.

Effect of Blending on Coke Properties: In selection of coals for metallurgical use, as much attention is given to their blending properties as to their individual carbonizing behavior. Figs. 3 and 4 show the effect of blending various high volatile Pittsburgh district coals with both low volatile Pocahontas No. 3 and low volatile Beckley coals. The dry, mineral-matter-free fixed carbon content of the Pocahontas No. 3 coal ranged from 81.7 to 82.6 pct; that in the Beckley coal was 81.3 pct. The high volatile coals containing 59.9 to 67.7 pct dry, mineral-matter-free fixed carbon content include samples from all beds listed in Table I except Chilton, and although these figures were prepared for additions of 20 pct low volatile coal, similar relations hold for 30 pct or more. In addition to the range covered, a few data were available at fixed carbon contents below 57 pct, but they were not included for the following reasons: 1) it is doubtful that coals of this low fixed-carbon content would be used in binary blends with such low addition of low volatile coal; 2) the cokes yielded by these 100 pct high volatile coals were generally so weak that precision of the coke tests was poor; and 3) owing in part to lack of reliable indexes for the high volatile coals, the improvement in coke quality on addition of 20 pct low volatile coals was erratic.

Figs. 3 and 4 show that a reasonably close correlation exists between the coke tumbler indexes for the individual high volatile coals and their binary blends with both Pocahontas and Beckley low volatile coals. These data indicate 1) that coke stability is more affected by blending than coke hardness* and 2) that both factors are improved more for the cokes from weakly coking coals than for those from the strongly coking coals. For example, the addition of 20 pct low volatile coal to a high volatile coal yielding coke with a 1-in. tumbler index of 25 increases the stability index by 40 pct; when the 1-in. tumbler index is 50, improvement is less than 10 pct. Similarly with the ¼-in. tumbler index, the poorer coking coals are benefited most. For example, a ¼-in. tumbler index of 50 is increased 10 pct by blending the high volatile coal with 20 pct of either low volatile Pocahontas No. 3 or Beckley; a ¼-in. tumbler index of 65 is increased about 3 pct by such blending. Furthermore, for cokes with tumbler indexes approaching those for low volatile coals the slope of the curves approaches unity, so that the coke-strength indexes are not improved by addition of low volatile coal.

* A similar observation is noted in the discussion of Figs. 1 and 2.

Although the discussion thus far has been confined to blends of high and low volatile coals, additional tests have shown that coals high in the medium volatile rank impart coking strength to blends fully as well as low volatile coals. In blending medium volatile coals low in that classification, larger proportions normally are required to obtain coking properties comparable to those of low volatile blends. As the proportions of medium and low volatile coals used in blending are limited by their expanding properties, the expansion of these coals is an important factor in their carbonization.

Expanding Properties: As anticipated for a region in which the coals rank as high, medium, and low volatile bituminous, Pittsburgh district coals, both individually and collectively, vary greatly in expanding properties. For example, the Upper and Lower Freeport, Upper and Lower Kittanning, and Sewell beds, which extend over large areas and range widely in fixed carbon content, yield both contracting and expanding coals. Table II shows ranges in percent expansion as follows: Upper Freeport, −21.4 to 18.6; Lower Kittanning, −31.6 to 13.7; Lower Freeport, −19.3 to 21.8; and Sewell, −11.3 to 26.1. These ranges* should be considered as typical and not as representative of maximum values obtained in USBM tests for these beds. Although the range in expansion for the Pittsburgh bed is narrow for a bed so extensive, the values would undoubtedly spread much more if the samples included some from Maryland, where the bed contains high-rank-

* Apply to those samples tested in both the BM-AGA unit and the sole-heated expansion oven.

ing coals, and western Washington County, Pa., or eastern Ohio, where it ranks lower.

Expansion properties of coals in a single bed are not so well correlated with rank as are the coke-making properties of the coals, and the expansion data appear to be influenced by coal properties that are relatively unimportant in determining coke quality. Although previous work[8] has shown that coal expansion is related to the dry, mineral-matter-free fixed carbon content, with a correlation coefficient of 0.83 the relation is not sufficiently quantitative to permit accurate estimation of the expanding properties of coals from this simple relation. At present, if accurate expanding properties of coals are desired, it is necessary to make expansion tests. The data of Table II should be useful in giving the expansion range expected for coals from the beds listed. In general coals containing less than 68 pct mineral-matter-free fixed carbon contract, and their expansion increases with increased rank. However, such generalizations are not quantitative, and exceptions are notable.

Although the expansion properties of coals are not as yet quantitatively predictable from their rank and chemical analysis, expansion properties of blends of certain high and low volatile coals can be estimated closely from the known expansion of the high volatile coals. This is shown in Fig. 5, in which all the high volatile coals are Appalachian coals containing 56.7 to 68.4 pct dry, mineral-matter-free fixed carbon. The solid points represent beds outside the Pittsburgh district; the open circles represent Alma, Pittsburgh, Lower Freeport, Cedar Grove, Winifrede, and Campbell's Creek coals ranging from 60.5 to 67.7 pct fixed carbon content. Coals from areas outside the Pittsburgh district were included to establish the shape of the curve more accurately than would otherwise be possible. It is evident that if the expansion properties of the high volatile coals are known the expansion of their blends with 20 pct low volatile Pocahontas No. 3 coal can be predicted with reasonable accuracy. The Pocahontas No. 3 coals ranged from 81.7 to 82.6 pct in dry, mineral-matter-free fixed carbon. Fig. 5 shows that, in general, blends containing 20 pct Pocahontas No. 3 are either neutral or contracting if the high volatile component contracts more than 9 pct, and under most conditions such blends could be carbonized safely in commercial ovens. Similarly, high volatile coals that contract less than 9 pct are liable to expand dangerously when so blended. It should not be inferred that delineation between safe and dangerous coals is sharp, because overlapping does occur, owing in part to the different operating conditions on the plant scale. Expansion data in this report are referred to a common dry-coal bulk density of 54.5 lb per cu ft, which is higher than normal in commercial practice, and since the expansion in the sole-heated oven varies linearly with bulk density[8] and is an e function of bulk density in slot-type ovens,[9,10] lower bulk density is conducive to greater safety in operations. The data of Fig. 5 should be used as a guide to anticipated expansion problems when coal blends are changed rather than as a quantitaitve measure of the safety with which such blends can be used. Plots of this type will probably find their chief application in comparisons of the expansion characteristics of new coals with those whose expansion is known. These plots may be used as first approximations regarding the substitution of an untried coal for one that has been used successfully in commercial plants.

Conclusions

1) High volatile coals from the Pittsburgh, Upper and Lower Freeport, Upper and Lower Kittanning, Winifrede, Chilton, Cedar Grove, Alma, No. 2 Gas, Eagle, and Sewell beds are suitable metallurgical coals if they contain more than 60 pct dry, mineral-matter-free fixed carbon and are not high in ash and sulfur.

2) Medium and low volatile coals from the Upper and Lower Freeport, Upper and Lower Kittanning, Bakerstown, Eagle, Sewell, Beckley, Fire Creek, and Pocahontas Nos. 3, 4, and 6 are good blending coals even though they vary greatly in expanding properties.

3) Coke tumbler stability and hardness are related to the proximate analysis of the coal and form a reasonable basis for predicting the strength of cokes from Pittsburgh, Upper and Lower Freeport, and Upper and Lower Kittanning coals. Coke hardness is virtually independent of fixed carbon content in the range of 60 to 80 pct, whereas coke stability is more closely related. In general, Kittanning coals yield slightly weaker cokes than Freeport coals when compared at the same fixed carbon content.

4) The tumbler indexes of cokes made from single high volatile coals correlate well with those of cokes from their binary blends containing 20 pct Pocahontas or Beckley low volatile coals.

5) Although the expanding property of high volatile coals is not closely correlated with rank, the expansion of their blends with Pocahontas No. 3 low volatile coal can be closely estimated from the expansion of high volatile components.

6) In general, blends containing 20 pct Pocahontas No. 3 coal contract or are neutral if the high volatile component contracts more than 9 pct; they expand if the high volatile component contracts less than 9 pct.

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[10] F. W. Smith: Effect of Temperature, Charge Density, and Blending on the Carbonization of Coal. Paper presented at Annual Meeting of the American Coke and Coal Chemical Institute, White Sulfur Springs, W. Va.

Discussion on this paper sent (2 copies) to AIME before May 31, 1957, will appear in MINING ENGINEERING.

aime news

Reno to be Site of Mineral Conference in May

Conference general chairman is Dean Vernon Scheid, University of Nevada.

The first Pacific Southwest Mineral Industry Conference, sponsored by the AIME Nevada Section, and co-sponsored by the Southern California and San Francisco Sections, will be held in Reno, Nev., April 5-6, 1957.

Four technical sessions are scheduled for the first day at which time papers on geology, mining, metallurgy and industrial minerals will be presented, five or more papers at each session. Included are papers on *Mineral Belts in Nevada*, by R. Roberts, USGS; *Phosphate Sands in the Economy of the Pacific Rim*, by W. Smiley; *Raw Materials in the West;* and *Hole Methods of Mining and Development.*

Two field trips are planned for April 6. A visit to the diatomite mine and mill of the Eagle-Picher Co. at Clark Station, Nev., and the open pit gypsum mine and board plant of the U. S. Gypsum Co. at Empire, Nevada, will be made through the Truckee River Canyon and Pyramid Lake, a remnant of prehistoric Lake Lahontan. Stops will be made at points of interest along the way. The second trip will be to Anaconda Co.'s open pit copper mine and plant at Weed Heights, Nev. Anaconda produces its own sulfuric acid from sulfur ore mined at the Leviathan mine in Alpine County, Calif. The return trip will be made via Virginia City and the Comstock Lode. Tours are also planned to the Mackay School of Mines at the University of Nevada in Reno.

Social events will include a luncheon, April 5, in the Fable Room, Mapes Hotel, and a cocktail party and dinner April 5, in the Redwood Room, Riverside Hotel. George A. Kiersch, geologist for the Southern Pacific Railroad and former director of the Mineral Resources Survey, Navajo-Hopi Indian Reservation, will address the luncheon on the subject of *Geological Investigations-Applications in Developing the Mineral Resources of a Region.*

Although the ladies are invited to participate in all events, a special smorgasbord luncheon will be held for them on April 5, at the Mapes Hotel. They will also visit Virginia City and Carson City on April 6.

Those attending will be left on their own, the night of April 6, and are certain to find Reno well-equipped with amusement places.

Advance registration material, reservations and programs may be obtained by writing to: William P. Johnston, Registration Chairman, 3200 West Plumb Lane, Reno, Nev.

Regional Meeting Set For October in Florida

The Florida Section is busy planning for the forthcoming Southeastern Mining Branch Regional Conference to be held in Tampa, Fla. on Oct. 15-18, 1957.

This will be a four-day meeting, starting with two days of technical sessions, followed by two days of field trips. An interesting program is being developed by J. L. Weaver of the American Cyanamid Co. at Brewster, Fla. Co-chairmen are H. E. Uhland and Harry M. Feigin.

Among the field trips already listed are the following: Field trip to the Jacksonville area to study the heavy mineral deposits (exploration, mining and beneficiation); Field trip through the phosphate fields of the Bartow-Brewster area, including visits to the mines, a flotation plant, a triple super phosphate plant, and an electric furnace operation. To date, the total value of phosphate produced from this field amounts to $1.4 billion.

Interesting events planned for the ladies include a beach party and a trip to Cypress Gardens.

The Hillsboro Hotel in Tampa will be registration and session headquarters. Charles H. Greene, Davison Chemical Corp., Bartow, Fla., is chairman of arrangements and reservations.

Pacific Northwest Meeting in Portland

Plans for the AIME 1957 Pacific Northwest Regional Conference are nearing completion, according to Don W. Johnson, general chairman. Scheduled for April 11-13, at the Multnomah Hotel, Portland, Ore., the meeting will feature an imposing roster of speakers including Dr. A. B. Kinzel, president, Union Carbide & Carbon Research Laboratories Inc. Dr. Kinzel will address the Friday night banquet on the subject of *Research in the New Metallurgy.*

Also slated to speak are: General Leslie B. Simon, vice president, Carborundum Co.; R. R. McNaughton, Consolidated Mining & Smelting Co., Trail, B. C.; Elmer C. Tveter, Dow Chemical Co.; D. W. McGlasham, Montana School of Mines; Ben H. McLeod, Dorr-Oliver Co.; George Beard, Pacific Power & Light Co.; H. F. Yancey, USBM; and L. R. Ramp, Oregon State Department of Geology.

Field Trips

A field trip is planned to nearby Albany, Ore., to visit the Oregon Metallurgical Corp., the Wah Chang Corp., and the Bureau of Mines. On Thursday afternoon members will have an opportunity to visit the Portland Owens-Illinois Glass plant, a multi-million dollar project, recently completed.

For the Ladies

Special events have been arranged to keep the distaff busy and happy. On Thursday they will make a scenic tour of the Portland area. Also planned is a get-acquainted coffee hour, followed by a luncheon and fashion show.

The grand finale on Friday evening will include cocktails, a banquet and a dancing party in the Grand Ballroom of the Multnomah Hotel.

Registration for the meeting begins at noon on Wed., April 10, and will cost $4.00 for members, $6.00 for nonmembers, and $1.00 for the ladies.

Inquiries and mail registration should be directed to: Edward A. Vistica, 304 Public Service Building, Portland, Ore.

EJC General Assembly

A partial view is shown of the head table at the Unity Dinner, on Jan. 17, during the Engineers Joint Council annual meeting in the Statler Hotel. Left to right, J. W. Barker, EJC President; T. B. Counselman, AIME Vice President; Paul Weir, President, American Water Works Assn.; and W. L. Everitt, President, American Society for Engineering Education.

EJC Report on Income

The Engineers Joint Council report of Professional Income of Engineers—1956, is now available. It is based on figures compiled on about 110,000 engineering graduates employed in industry, government, and education. The data is presented in various graphic and tabular forms, similar to the 1953 report, to facilitate analysis, statistical comparison, and the development of trends. EJC will accept orders for the report, at $1.50 per copy.

Upper Peninsula Section Co-sponsors Geology Meet

The Exploration Subsection of AIME Upper Peninsula Section, in cooperation with the Institute on Lake Superior Geology will hold their annual meeting May 6-8, 1957. Michigan State University is host, and the Kellogg Center on campus will be the site of the meetings. Other sponsors are the Michigan Geological Survey and the Michigan Geological Society. Theme for this conference is: *Modern Research Techniques and Stratigraphic Concepts Applicable to Pre-Cambrian Geology.*

Competent authorities in the fields of sedimentation, stratigraphy and metamorphism will present their viewpoints with the hope that some of the knowledge can be applied to pre-Cambrian geology. Sufficient time will be available for the presentation of papers and discussions.

Much of the overall planning has been completed and the various committees are now working on final details. Field trips are being planned to a Detroit steel mill and to Abrams Aerial Survey. The social committee is making suitable arrangements for evening entertainment and a banquet, and there will also be a varied program for the wives attending.

Within a short time more specific details of the meeting will be sent out, and the blanks for submitting titles, abstracts and for early registration will be included. Those wishing to present papers are urged to prepare the titles and abstracts now, so that these can be submitted promptly.

Suggestions concerning this meeting will be gladly accepted. Write to Justin Zinn, secretary, Dept. of Geology, Michigan State University, E. Lansing, Mich.

Thiessen Medal Award

The late Dr. Reinhardt Thiessen, AIME member, who was associated with the USBM in Pittsburgh until his death in 1938, has been honored by the International Commission on Coal Petrology. The Commission has established an award, the Thiessen Medal, for outstanding contributions to the field of coal petrology. The first presentation was made on Dec. 11, 1956, to C. A. Seyler, on the occasion of his 90th birthday.

Working in the same field as his illustrious father, Gilbert Thiessen is currently assistant manager, research department, Koppers Co. Inc., Verona, Pa.

Ceramic Engineering Scholarship Increased

The first scholarship-loan fund for students of ceramic engineering, established 1955 at the Missouri School of Mines & Metallurgy, Rolla, Mo., has received an additional gift from donors, J. B. Arthur and family. The fund, named in their honor, is in the form of stock in Mexico Refractories Co., of which Mr. Arthur is president. His recent contribution of 400 shares of stock brings the total to 820. The stock is valued currently at $35 a share. Recipients of the Arthur Scholarship, who must be in their junior or senior year, receive a $500 grant and a $200 loan for a year.

Do Oldsters Want Jobs

Are there many or few retired engineers, or others past fifty, able and willing to take temporary jobs in engineering? Engineering Societies Personnel Service (ESPS), the employment agency for the engineering societies, wants to know.

The current shortage of engineers and scientists is a well known fact. Continuous advertising in the newspapers of metropolitan areas and the quarterly combing of our campuses emphasize the need for young engineers and scientists. The supply does not begin to meet the demand for young men in these fields. Is the shortage confined to the young men, or does it include men in the older brackets in industry and government? Is it possible to partially meet today's need for engineers and scientists by temporary employment of men no longer young but willing and able to perform the required task? If such men are available and employers want them as temporary help, the task of trying to get employers and prospective employees together will be undertaken by ESPS.

There are deterrents and complications in any attempt to employ older or retired engineers even temporarily on routine work. Some of the largest companies, whose engineer recruitment efforts are the most impressive, will not hire engineers or scientists over 35. Their reasons are sound where permanency in an organization is envisaged. But temporary, day by day, or week by week, employment of men to help level off peak loads need not affect the retirement system of a company nor interfere with lines of promotion, apprenticeship jobs and other factors vital to employment planned on a permanent basis.

From the viewpoint of the older prospective employee, the 50-plus man or the Social Security beneficiary over 65, there are deterrents too. These would tend to dampen the desire to take a position by the day or week as a temporary helper, without becoming an integral part of an organization. Granting the handicaps which exist from the viewpoint of both employer and prospective older employees, it still seems reasonable that some of the shortage of engineers could be met by greater use of the older members of our profession who are now unemployed or retired.

ESPS does not now know how many of such potential employees are available. If *you* are an engineer or scientist over 50, unemployed or retired, and if you are willing and able to take a temporary job, please tell ESPS. Send a brief letter to Engineering Societies Personnel Service, 8 W. 40th St., New York 18, N. Y., including your professional branch, specialty, age, and refer to

(Continued on page 367)

ESPS Personnel Service

(Continued from page 366)

this article. If the response is adequate, the ESPS Board will attempt to work out a plan to bring older engineers and scientists together with the industries that need them.

ESPS, with offices in New York, Chicago, Detroit and San Francisco, continues ready to help any engineer or scientist of any age better his position or obtain one. ESPS also tries to locate the particular engineer or scientist any specific employer may want. These have been the routine tasks of ESPS for more than 25 years. The proposal discussed here contemplates a special kind of placement from a yet unknown number of prospects, 50-plus in years, who still desire to help themselves and their profession in the work of the nation.—*Wm. N. Carey, Secretary Emeritus, ASCE.*

Pacific Southwest Conference Plant Tour

One of the tours planned in connection with the Pacific Southwest Mineral Conference in Reno next month, is a visit to Anaconda Co.'s open pit copper mine and plant, pictured above, located in Weed Heights, Nev.

Los Angeles to Be Host To Regional Conference Scheduled for May 1957

Metals for Today and Tomorrow is the theme of the Second Regional Reactive Metals Conference to be held May 28-29, 1957 at the Ambassador Hotel in Los Angeles, sponsored by the AIME Southern California Section.

Topics to be Covered

The conference will be concerned with the resources, production, fabrication, properties and use of such metals as: beryllium, boron, cerium, columbium, gladolinium, hafnium lanthanum, molybdenum, potassium, rhenium, solium, tantalum, titanium, thorium, tungsten, uranium, vanadium and zirconium.

Equipment Exhibits

Exhibits have been prepared by prominent companies to show equipment important in the mining and processing of reactive metals as well as examples of fabrication techniques.

Technical Sessions

The Metals and Mining Branches will hold concurrent meetings on the first day, and joint meetings on the second. Tentative program arrangements are as follows: On Tuesday morning, May 28, there will be a mining session on raw materials resources and exploration, with papers on world potash resources, borate, and uranium exploration. The concurrent metals session will center on the metallurgy of titanium, zirconium, and hafnium, and will include a paper on the casting of titanium.

The Mining Branch Luncheon at noon on Tuesday will feature a talk of special interest. In the afternoon the mining session will cover mining operations for tungsten, molybdenum, potash, and rare earths. The Metals session that afternoon has scheduled papers on fabrication techniques for reactive metals, including vacuum melting, extrusion, and forging, welding and powder metallurgy.

Dinner Speaker

The dinner on the evening of May 28, will feature James Boyd, former USBM director, who is now vice president of Kennecott Copper Corp. Mr. Boyd will speak on *The Effect of the Location of Reactive Metal Resources on the Industrial Development of the U. S.*

Joint Sessions

On the morning of May 29, the Joint Mining and Metals Session will include papers on beneficiation, refining, and future trends in thorium, alkaline metals, and titanium electrometallurgy. Bruce S. Old, president of Nuclear Metals, is slated to discuss *Current Interests in Reactive Metals*, at the Wednesday luncheon. The joint session that afternoon will include talks on the metallurgy of vanadium, the mechanical working of arc-cast molybdenum alloys, on beryllium, niobium, and tantalum.

Registration and Information

Registration fee for AIME members is $3.00, and $5.00 for nonmembers; students will be admitted free. Further information about the conference can be obtained from Benjamin S. Mesick, 727 W. 7th St., Los Angeles 17, Calif.

Minerals Meeting Set For October in Denver

The Fourth Annual Rocky Mountain Minerals Conference, scheduled for Oct. 30, 31 and Nov. 1, 1957, in Denver, has announced the General Committee Chairmen. E. H. Crabtree, general chairman will be assisted by R. L. Scott; L. J. Parkinson is program chairman; C. L. Barker, arrangements; G. M. Wilfley, entertainment; A. L. Hill, budget; Mrs. P. P. Harrison, Women's Auxiliary; and F. L. Smith, secretary.

The tentative program includes five technical sessions. Division luncheons and a suppliers' cocktail party will be held on Oct. 30, while the formal luncheon with AIME President is scheduled for Oct. 31. On Nov. 1, a dinner-dance is on the agenda, and a field trip is planned for Saturday, Nov. 2, to wind up the meeting.

NOTE

A limited number of copies of *Mining Branch Abstracts*, prepared for the AIME Annual Meeting in New Orleans, Feb. 24-28, 1957, are still available. Copies can be obtained by writing to Arnold Buzzalini, Society of Mining Engineers of AIME, 29 W. 39th St., New York 18, N. Y., and enclosing 50¢. Please indicate your Divisional interest at the time you order.

Around the Sections

• When the **Washington, D. C. Section** met on Jan. 8, at the Cosmos Club, Elmer Pehrson, chief, Div. of Foreign Activities, Bureau of Mines, was the featured lecturer. Mr. Pehrson, who recently returned from a four-month tour of Asia and Europe where he inspected Bureau of Mines technical assistance projects, spoke on *Oil, Suckers, Jews, and Arabs.* He illustrated his talk with kodachrome slides.

The following officers were elected to serve in 1957: Rafford L. Faulkner, chairman; Charles W. Merrill, Bruce C. Netschert and Clifford J. Williamson, vice chairmen; and Jesse A. Miller, secretary-treasurer.

• The **MBD Subsection** of the **Minnesota Section** met at Chisholm, Minn., on Nov. 14, at which time they heard R. J. Priestley, Dorr-Oliver Inc., discuss FluoSolids roasting, with particular emphasis on the conversion of hematite to magnetite. A large turnout attested to the success of the meeting.

• The **Black Hills Section** met 6:30 pm, Jan. 10, at the Rod & Gun Club Bldg., Lead, S. D. After the regular business meeting which included discussion of the Annual Meeting and instructions to the Section delegate, a film, *Portrait of the Earth*, was shown. Members then gathered for a Dutch Lunch.

• When the **Oregon Section** met in Portland on Jan. 18, at the Buons Restaurant, W. Funke, manager, Owens-Illinois Portland plant, addressed the group. He gave a brief description of the plant operations, after which the members adjourned for a tour of the plant.

• The **Florida Section** offered its members an educational program on Nov. 5 at the University of Florida in Gainesville. Guest lecturer Dean J. Weil, College of Engineering, spoke on *Nuclear Energy and Florida.* The program was arranged by E. S. Beebe and G. F. Coope, Jr., and included a tour of the Engineering and Industries Building.

Past-President Reistle addressed the Section on Jan. 14, on the romance of the oil business, in which he has been engaged since 1919. The new Section officers were then introduced. They are: Charles Chapman, chairman; C. H. Greene, vice chairman; and H. R. Quina, secretary-treasurer.

The Section met on Feb. 11 at the Glass Diner Restaurant in Lakeland, to hear a talk on the manufacture of sulfuric acid by the contact process. A discussion followed, on the topic of corrosion problems encountered in the manufacture of triple superphosphate.

• The **Chicago Section** featured a meeting on the much neglected topic of jasper ores, when they convened on Jan. 2, at the Chicago Bar Assn. Harold E. Rowen, general manager, Dwight-Lloyd Div., McDowell Co., gave a lecture on *Some Developments in Pelletizing Jasper Concentrates.* The meeting was conducted by Technical Chairman Roy P. Wheatley. The Section met again on Feb. 6, at which time F. M. Richmond, research head, Universal Cyclops Steel Corp. discussed *Properties of Vacuum Melted Materials.*

• The **Southwestern New Mexico Section** held a technical session Oct. 30, in the Bayard Lions Club Building. The program consisted of the presentation of two papers: *Wire Line Diamond Drilling at Chino* by W. W. Baltosser, and *Advent of 12-inch Drilling at Chino* by D. D. McNaughton. A question and answer period followed.

• The **Connecticut Section** met on Jan. 22, at the Hammond Metallurgical Laboratory, Yale University, New Haven. Featured speaker was D. K. Crampton, Chase Brass & Copper Co., Waterbury, Conn., who discussed *Structural Chemistry and Metallurgy of Copper.* This meeting was also Annual Students' Night, and interested engineering students were in attendance.

• The *Colorado River Project* was the topic chosen by guest speaker E. O. Larson when he addressed the **Utah Section** on Jan. 17, at the Newhouse Hotel, Salt Lake City. Mr. Larson, who is regional director, U. S. Bureau of Reclamation, discussed engineering aspects of this project.

• The dinner-meeting of the **Colorado Section** on Jan. 17, at the University Club in Golden, featured a talk by E. J. Eisenach, general superintendent, Climax Molybdenum Co. He spoke on *Advanced Management Program of Harvard Business School*, explaining that this concentrated three-month course is designed to acquaint administrative personnel with the latest techniques in management.

• The **Montana Section** was treated to a color feature film, *Our Mr. Sun*, when they met with the Montana Society of Engineers and the AIEE on Jan. 11, in the Museum Auditorium, Montana School of Mines in Butte. Produced by American Telephone & Telegraph Co., the picture presents the technical aspects of the focus of our solar system in a manner easily understood. Stanley M. Lane was elected section chairman; Edward P. Shea, vice chairman; and Clifford J. Hicks, secretary-treasurer.

• Conrad Martin, geologist, Basic Refractories Co., Gabbs, Nev., was guest speaker at the **Reno Subsection** meeting on Jan. 11, in the Mapes Hotel. He discussed *The Occurrence and Mining of Magnesite Ores at Gabbs*, and then showed color slides. The following officers were elected for 1957: A. L. Engel, chairman; H. P. Ehrlinger, III, vice chairman; and M. Steinheimer, secretary-treasurer.

CF&I's new film *Make Mine Safety* **shows in simple terms the puzzles of rock bolt application and manufacture, and also details some of the types available. The bulk of the sound-color 16 mm film is devoted to showing bolts being installed underground in various Western mining operations.**

Prints are available for use by interested groups from: T. J. Barbre Productions, Film Library, 2130 S. Bellaire Street, Denver 2, Colo.

Three industrial films are now available at no cost, from Christensen Diamond Products Co. Offered for showings at association meetings or conventions, these films are all 16-mm color with sound and average 25 min. Any one film or all three, may be obtained.

Film 1 deals with diamond production in South Africa and shows how diamonds are recovered from the famous Kimberly Mine and from alluvial deposits. Of special interest to those who have seen or used diamond bits in the field, Film 2 shows how these bits and barrels are manufactured. Through the eye of the camera, the viewer takes a brief tour of the Christensen plant in Salt Lake City.

Film 3 shows the application of diamond products and their use in the petroleum, mining, and construction industries. Address requests for these films to: Christensen Diamond Products Co., P. O. Box 387, Salt Lake City 10, Utah. In the event of any duplication in requests, the parties concerned will be advised and arrangements made for rescheduling.

A 17-min film recently released by Atlas Powder Co. points up startling parallels in the hazards of dealing with dynamite and damsels. Entitled *How to Handle Women and Explosives,* **it demonstrates safety practice with regard to explosives in mining, contracting, and seismic exploration and stresses the importance of accident prevention. This film may be obtained free of charge from the Explosives Development Section, Atlas Powder Co., Wilmington 99, Del. Brochures of** *Do's and Don'ts* **will be sent in the program kit, along with the movie.**

PERSONALS

Two AIME members, father and son, have recently been appointed to new positions. **Henry B. Parfet** is manager of Compañia Minera Choco Pacifico, Cali, Colombia, while **H. B. Parfet, Jr.** is sales engineer for Electro Metallurgical Co. in the company's Chicago office.

Four Coeur d'Alene district mining men have accepted appointment to the University of Idaho research advisory council for the current biennium. They are: **John D. Bradley**, president, and **Wallace G. Woolf**, general manager, The Bunker Hill Co.; **R. D. Leisk**, retired vice president of Sunshine Mining Co.; and **Robert E. Sorenson**, vice president, Hecla Mining Co. Also on the 40-member council is **Harry W. Marsh**, secretary, the Idaho Mining Assn.

Earl K. Nixon, consultant geologist and mining engineer of Lawrence, Kan., recently returned from Chihuahua, Mexico, where he had been doing examination work.

Carl W. Westphal, founder member No. 2 of the Lima, Peru, Local Section founded in 1952, recently returned to the United States. In recognition of his activity, Mr. Westphal was presented with a silver plate engraved with the AIME emblem. **Edgardo Portaro**, chairman-elect of the Section, made the presentation.

Alvin J. Thuli, Jr., was promoted to chief engineer, Utah Copper Div., Kennecott Copper Corp. He had been assistant chief engineer. Mr. Thuli has been appointed general chairman of the 1958 Rocky Mountain Minerals Conference.

Hal J. Jones is chief engineer, Houston Technical Laboratories, Houston. He had been senior geophysical engineer for Texas Instruments Inc. in Dallas.

W. F. Galloway is now mill superintendent, MacLeod-Cockshutt Gold Mines Ltd., Geraldton, Ont., Canada.

John Naylor has left Cerro de Pasco Corp. to open his own engineering consulting office in Lima, Peru.

Henry P. Ehrlinger III, has accepted a position with the American Smelting & Refining Co., El Paso, Texas. Vice chairman and formerly secretary of the AIME Reno Sub-Section, he had been studying for the M.S. degree at the Mackay School of Mines. His new position is returning Mr. Ehrlinger to the Mexican Mining Dept., where he worked prior to his post-graduate studies.

Oscar M. Wicken is now assistant manager, Bonneville Ltd., Salt Lake City.

V. D. PERRY

The Anaconda Co. has announced several personnel changes. **Vincent D. Perry,** chief geologist for the company, was recently elected a vice president. A graduate of the University of California and Columbia University, where he received his master's degree in mining geology, Mr. Perry has held geological management posts at Anaconda since 1924.

In the Reduction Dept., Anaconda, Mont., the following promotions have been announced:

W. A. Emanuel has been appointed manager, succeeding **William E. Mitchell,** while **John Bolles** advances to concentrator metallurgist.

Mr. Mitchell, whose retirement after 45 years of service took place recently, will continue as metallur-

W. E. MITCHELL

gical consultant. Mr. Emanuel, a graduate of the University of Wisconsin, began his career with Anaconda in the chemical and research engineering departments and rose to become superintendent of the laboratory sample mill, dust plants and the zinc plant. In 1955 he was promoted to general superintendent of the Reduction Dept. Mr. Bolles has been serving as assistant superintendent of concentration.

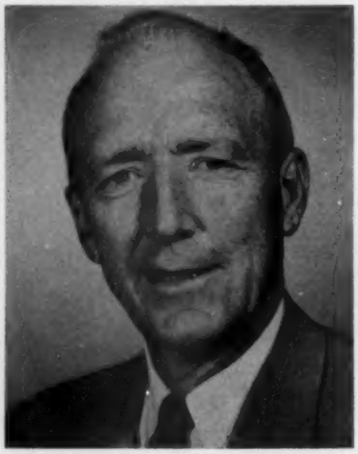
Brian P. Canning is assistant metallurgist, American Smelting & Refining Co., Silver Bell, Ariz.

Eugene Callaghan, formerly director of the New Mexico Bureau of Mines and Mineral Resources, has been appointed chief geologist in charge of exploration for Haile Mines Inc. of New York. Field headquarters have been established at Salt Lake City. Prior to coming to New Mexico in 1949. Mr. Callaghan was professor of economic geology, Indiana University and economic geologist for the Indiana Geological Survey. Following completion of graduate work at Columbia University, he was a geologist with the USGS for 16 years.

E. CALLAGHAN

Elliot J. Brebner became mine engineer for the St. Joseph Lead Co., Flat River, Mo., on completion of his military service.

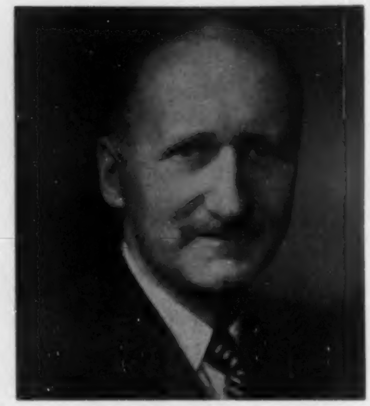
Max J. Kennard has been named chief engineer, Engineering and Construction Div., Southwestern Engineering Co., Los Angeles. He had been vice president in charge of sales and development at Combined Metals Reduction Co., Salt Lake City.



M. J. KENNARD

Robert L. Squires is field engineer, J. F. Pritchard & Co., Peoria, Ill.

Leonard J. Keller is now quarry engineer, U. S. Gypsum Co., Sweetwater, Texas.



R. P. KOENIG

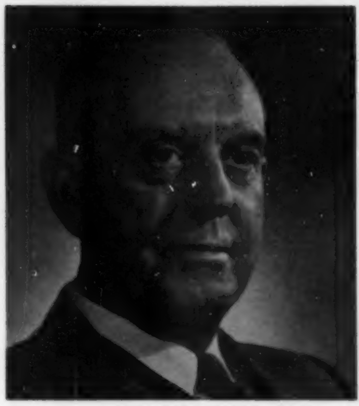
Robert P. Koenig and **A. Russell Merz** have been elected presidents, respectively, of Cerro de Pasco Corp. —Delaware, and Cerro de Pasco Sales Corp., subsidiaries of the N. Y. organization, of which they are president and vice president, respectively.

A. R. MERZ

Theodore A. Dodge, vice president of Hoagland & Dodge Drilling Co., Tucson, Ariz., and consulting mining geologist, has returned to Tucson after four months in Mexico and Spain.

T. A. DODGE

Ralph D. Parker, a vice president of The International Nickel Co. of Canada Ltd., has been elected a director. Mr. Parker, who joined the company in 1928, is president of the Canadian Nickel Co. Ltd., Inco's exploration and prospecting subsidiary.



R. D. PARKER

C. A. Romano has transferred from Intermountain Chemical Co., Green River, Wyo., to the San Jose, Calif., offices of Food Machinery & Chemical Corp.

Richard E. Joslin has left the Fairmont Machinery Co. to become preparation manager, Clinchfield Coal Co., St. Paul, Va.

L. K. Marshall is mine superintendent, Tambun Mining Co. Ltd., Ipoh, Perak, Malaya.

Hubert L. Barnes is with the Geophysical Laboratory in Washington, D. C.

Howard H. Braden is in the engineering department of Calera Mining Co., Blackbird Div., Cobalt, Idaho.

V. Cisneros, Jr., has left Minas de Iguala, S. A., in Mexico to become manager of Cía Minera Huehuetenango, S. A. in Guatemala.

Charles W. Schlotter is now sales engineer, Wm. H. Taylor & Co. Inc., Allentown, Pa.

Lloyd Pollish, formerly assistant research engineer at The Anaconda Co., Butte, Mont., is now associated with Andes Copper Mining Co., Potrerillos, Chile.

Evaristo Martinez has changed his company affiliation from The Anaconda Co. to Gardner-Denver Co. in Quincy, Ill.

Robert T. Sanden is with Electro Metallurgical Co. in Niagara Falls, N. Y. He had been assistant research metallurgist for the Hanna Coal & Ore Corp., Hibbing, Minn.

J. C. Nixon of The Zinc Corp. Ltd. and New Broken Hill Consolidated Ltd., Australia, is managing the Anzin Development Laboratory, a new mineral dressing research unit in Avonmouth, England, sponsored by the Anglo American Corp. of South Africa Ltd. and Consolidated Zinc Corp. Ltd.

Robert M. Burdan is in Ciudad Bolivar, Venezuela, working as a consulting geologist for the Orinoco Mining Co.

K. E. Mantell has transferred from Northern Rhodesia to the London offices of Nchanga Consolidated Copper Mine Ltd.

B. A. BRAMSON

Bernard A. Bramson, until recently First Secretary to the U. S. Embassy at Lima, Peru, and Minerals Attaché for the west coast of South America, has been transferred to South Africa. With headquarters at the American Consulate General in Johannesburg, he will cover mineral activities in the Union of South Africa, Northern and Southern Rhodesia, Southwest Africa, Mozambique, and Madagascar.

W. O. Binder has been appointed assistant manager of the product and process development department, Electro Metallurgical Co., Niagara Falls, N. Y. He will be joined in that department by **E. R. Saunders,** assistant to the manager, who will be in charge of the laboratory.

D. H. Harraway is studying for a master's degree in mineral engineering while working as assistant to **S. R. B. Cooke** at the University of Minnesota, Minneapolis.

John V. A. Sharp has completed his service with the U. S. Marines Corp. and is now a geologist with the AEC, Grand Junction, Colo.

Snapped on the scene in Cuba where they were working are three AIME members. Left to right, Alfred D. Wandke, Roger V. Pierce, and Marion Casper.

At Charco Redondo mine, Santa Rita, Cuba, are **Alfred D. Wandke, Roger V. Pierce** and **Marion Casper.** Mr. Wandke is consulting geologist in charge of exploration and development work, while Mr. Pierce, who is the new vice president of AIME, is acting as consultant on management and mine production. Mr. Casper is underground mine superintendent for the same operation.

W. R. McDaniel of Peoria, Ill., is now in Ciudad Bolivar, Venezuela, with Orinoco Mining Co.

John L. Boardman has retired as chairman of The Anaconda Co.'s Bureau of Safety after 40 years of safety work. Prior to joining the company in 1916, Mr. Boardman had worked for the USBM Mine Rescue Service. Author of numerous papers on accident prevention, he was awarded the gold medal and certificate of the Joseph A. Holmes Safety Assn. in 1917 for rescue of a worker at the risk of his own life.

J. R. BOGERT

John R. Bogert, formerly mining geologist with Cerro de Pasco Corp., is now chief geologist for the National Lead Co., S. A., Buenos Aires, Argentina.

Luther M. Krupp, resident engineer at Isbell Construction Co., Reno, Nev., has been transferred to the lead-zinc mine of American Smelting & Refining Co., Northport, Wash.

Clair C. Chamberlain has left the staff of Idarado Mining Co., Ouray, Colo., where he had been chief engineer, to become mine superintendent, at Cape Province, O'okiep Copper Co., Ltd., Union of South Africa.

Gabor Dessau has resumed his duties in Haifa, where he is establishing a mining engineering department at the Israel Institute of Technology, after a trip to Mexico where he attended the Geological Congress.

Charles O. Parker II, a graduate of the Colorado School of Mines, has been awarded the Mineral Engineering Fellowship for two years of study at the Harvard Business School.

Gale A. Hansen has taken the post of superintendent at New Park Mining Co., Keetley, Utah. He was formerly resident manager for Northwest Uranium Mines Inc., Spokane.

J. H. WREN

James H. Wren, of J. H. Wren & Co., Sacramento, Calif., consultants in mining engineering, will open a branch office in Salt Lake City to handle Utah uranium and eastern Nevada tungsten accounts.

Pierre C. Delaitre has joined the Division of Program, Technical Assistance Administration at United Nations headquarters in New York.

Ernest C. Simkins, formerly assistant mine superintendent at the Bingham Canyon open-pit copper mine, was appointed director of labor and personnel at Utah Copper Div., Kennecott Copper Corp., Salt Lake City. The company also announced the appointment of **Ray F. Gough** as assistant mine superintendent at the division.

Personals

(Continued from page 372)

Glen Leon Butt is now with Rare Metals Corp. of America, Tuba City, Ariz.

James A. Ndulue has left the Montana School of Mines for the Nigeria Dept. of Mines, Northern Nigeria, W. Africa.

Charles L. Golding has left Venezuela to join the United Geophysical Co. in Libya, North Africa.

Azad Mardirosian is attending Utah University for graduate credits in geology.

Robert T. Chapman has gone to Buenos Aires for a position with Sociedad Minera Argentina.

Donald W. Bobzien is with Cía Minera Nacional, S. A., in Taxco, Mexico.

Donald L. Simpson is an engineer-trainee at the Ray Mines Div., Kennecott Copper Corp., Ray, Ariz. **Kenneth Vance** has been named assistant drilling and blasting boss at the Ray Div., following the completion of his training program.

James T. McMullan resigned his position with Atlas Copco Eastern Inc., Paterson, N. J., and is now sales representative for Brunner & Lay Inc., Franklin Park, Ill.

Joseph T. Clark now superintends plant No. 1 at Leece-Neville Co., Cleveland.

F. S. Rooney has transferred from New York to the Pocatello, Idaho, office of Westvaco Mineral Products Div., Food Machinery & Chemical Corp.

Albert K. Smith, Jr., is chief engineer at Resurrection Mining Co., Leadville, Colo.

Consultants Please Note:

The office of the Mining Branch Secretary would like to revise and bring up to date their files on members who serve as **full time or part time consultants** to the Mining Industry. This information is needed to properly answer the many requests which are directed to our attention by persons writing in from all parts of the world. If you are interested in having your name listed and kept in this up-to-date file, kindly send your name, latest permanent address, and special field of endeavor or service as a consultant on a "Two Penny" Post Card to: **Arnold Buzzalini, Society of Mining Engineers of AIME, 29 West 39th Street, New York 18, N. Y.**

OBITUARIES

Everette Lee DeGolyer

An Appreciation by
Lewis W. MacNaughton

Everette Lee DeGolyer (Honorary Member 1914), senior chairman of the board of DeGolyer & MacNaughton, consultants to the petroleum industry, and director of many companies engaged in the petroleum and related industries, died at his office in Dallas on Dec. 14, 1956.

Mr. DeGolyer, who was affectionately known to his many friends as "De," was born on Oct. 9, 1886, of pioneer parents on a farm near Greensburg, Kan.

Mr. DeGolyer's interest in geology began even before he attended the University of Oklahoma. During his summer vacations he worked with the USGS, attracting the attention of C. W. Hayes. Shortly thereafter, Dr. Hayes, who was then building the geological staff of the Mexican Eagle Oil Co. Ltd., encouraged him to join his staff beore graduation. While in Mexico, Mr. DeGolyer staked the location for the Potrero Del Llano Well No. 4, one of the world's largest oil wells. He returned to the University and was graduated with a B.A. in geology in 1911, after which he was appointed chief geologist of Mexican Eagle Oil Co. Ltd.

From this point onward, his organizational ability was displayed in many of his activities. He helped form the Amerada Petroleum Corp. in 1919 and in 1925 its subsidiary, the Geophysical Research Corp. He also aided in the organization of Geophysical Service Inc. Another pioneering service company, Core Laboratories Inc., was formed at his instigation. After he resigned as Board Chairman of Amerada, he organized his own small company, the Atlatl Royalty Corp., where his primary interest lay in exploring for new oil fields. Although he was instrumental in organizing a number of companies engaged in various phases of the petroleum industry, he much preferred to study and analyze and explore situations rather than handle administrative details. In 1936, Lewis W. MacNaughton joined with him as consultants for the petroleum industry. This association was formalized under the name of DeGolyer & MacNaughton on Jan. 1, 1939, and Mr. DeGolyer remained the active senior member of this firm until his death.

During these years, Mr. DeGolyer also devoted much time to a wide variety of other activities. He was Distinguished Professor of Geology at the University of Texas in 1940, and was with the Petroleum Administration for War in Washington for over two years. He also served with the Interstate Oil Compact Commission, National Petroleum Council, Military Petroleum Advisory Board, and the AEC Advisory Committee on Raw Materials. He was a member of the Council and a fellow of the Geological Society of America, a director of the American Petroleum Institute, and one of the founders and a past president of the American Assn. of Petroleum Geologists. Last year he was appointed regent of the Smithsonian Institution by President Eisenhower.

Mr. DeGolyer's association with AIME was a long and active one, and he contributed some 50 papers to AIME publications. A member since 1914, he was a director from 1921 to 1926 and from 1928 to 1929. He was the first chairman of the Petroleum Div., 1923-1925, and was president of the Institute in 1927. He received the AIME Anthony F. Lucas Medal in 1940 and the John Fritz Medal from the Four Founder Societies in 1942 for "vision and leadership in developing and applying the art of geophysical exploration." In 1951 he was elected an honorary member of AIME.

Mr. DeGolyer received many other honors, including the following honorary degrees: Doctor of Science from the Colorado School of Mines, Southern Methodist University, Tulane University, and Washington University; Doctor of Law from Trinity College; Doctor of Engineering from Princeton University; and Doctor, Honoris Causa, from the University of Mexico. He was a recipient of the Sidney Powers Memorial Award of the American Assn. of Petroleum Geologists, and the first Distinguished Service Citation from the University of Oklahoma.

Mr. DeGolyer's rare capacity for simplifying complex problems so that they could be readily handled, influenced the thinking of many friends and associates. Likewise, his unusual ability in applying new concepts and methods to practical uses has had, and will continue to have, a lasting effect on the petroleum industry. Constant curiosity and love of research made his work a real pleasure to him, and the results brought him much fame and success. These qualities, which stimulated those around him to the full utilization of their talents, set him apart from other men.

Mr. DeGolyer is survived by his wife, Mrs. Nell Goodrich DeGolyer; three daughters, Mrs. John S. Maxson of Dallas, Mrs. George C. McGhee, and Mrs. Milton Arnold both of Washington, D. C.; a son Everette L. DeGolyer, Jr., of Dallas, and 13 grandchildren.

Memorial Resolution

EVERETTE LEE DEGOLYER

WHEREAS, with the passing of Everette Lee DeGolyer in Dallas, Texas, on December 14, 1956, the American Institute of Mining, Metallurgical, and Petroleum Engineers has lost one of its most distinguished members; and

WHEREAS, Mr. DeGolyer was, during his entire career, one of the most prominent engineers in the Mining and Petroleum profession, founder of a number of important oil companies, developer of many exploratory tools for the petroleum industry, and leading consultant in this field; and

WHEREAS, he had been a member of The American Institute of Mining, Metallurgical, and Petroleum Engineers since 1914 and an Honorary Member since 1951, and had served as a director of the Institute from 1921 to 1926 and from 1928 to 1929, and was president of the Institute in 1927; and

WHEREAS, he had received the Anthony F. Lucas Medal in 1940 and had received the John Fritz Medal in 1942 for his vision and leadership in developing and applying the art of geophysical exploration; therefore, be it

RESOLVED, that the American Institute of Mining, Metallurgical, and Petroleum Engineers record with deep sorrow the loss of this distinguished engineer, friend, and member; and be it further

RESOLVED, that this resolution be spread on the minutes of this meeting and a copy sent to the family of the late Everette Lee DeGolyer.

February 24, 1957 — **AIME Board of Directors**

V. F. Stanley Low (Legion of Honor Member 1901) died recently in Sydney, Australia, where he had been a consultant mining engineer. Born Jan. 23, 1871, in Victoria, Australia, Mr. Low studied at the University of Melbourne, receiving his B.A. degree in civil engineering in 1893. He joined the Mount Lyell Mining & Railway Co. Ltd., Tasmania, and was promoted to assistant engineer. By 1902 he was general manager, Broken Hill Co. Ltd., New South Wales. After a year as consulting engineer in Jamaica, B. W. I., he returned to Australia in 1955 as consultant with the National Bank of Australasia.

Arthur H. Keller (Legion of Honor Member 1883) died in Honduras, Central America, where he was a mining engineer with the Santa Rosa de Copan Co.

Ronald C. Rowe (Member 1943), widely known in Canadian and international mining and industrial publishing circles, died March 27, 1956 at the age of 66. Born in Norfolk, Eng., Mr. Rowe came to Canada in 1910, joining the Bell Graphite Co., Buckingham, Que., and turned his attention to the study of surveying, engineering practice, and mineralogy, becoming manager of the company at the age of 26. He was prominently identified with the graphite mining and refining industry as general manager for The North American Graphite Co., in Buckingham. During this period he designed and installed the first graphite flotation plant in Canada and also practiced as a consulting engineer. For many years a regular contributor to industrial publications, he became editor-in-chief of *Canadian Mining Journal.* He served as president of National Business Publications from 1946 until his death.

Frank Eichelberger (Member 1935) former director of Sunshine Mining Co., Spokane, died of a heart attack in his home at Hayden Lake, Idaho, on Oct. 21, 1956. He was 71 years old. His outstanding mining career took him into ten countries and included important services to his industry in three wars. During those years he was associated with the construction of 16 different milling, smelting, and metallurgical plants. In recent months his principal interest was the operations of Conjecture Mines Inc., near his home in Idaho. A graduate of Michigan College of Mines in 1908, Mr. Eichelberger took his first mining job while still in school. During World War I, he supervised construction of one of the first commercial flotation mills in Helena, Mont. In the early 1950's he helped found American Chrome Co. and in 1952 went to the Far East as a mining adviser to the South Korean government, examining tungsten and uranium deposits near the 38th parallel while war was raging there.

James H. Ratliff (Member 1940) died of a heart attack on Sept. 20, 1956. A native of Mancos, Colo. where he was born Jan. 12, 1879, his mining career dates back to 1914 when he was exploration engineer in Colorado and Utah. His last post was with Humphreys Gold Corp. in Denver.

Malcolm Glen (Member 1949) died recently in Australia, his native land. He was born in Melbourne on Sept. 2, 1907 and attended the University of Melbourne where he received his Bachelor's degree in metallurgical engineering. At the time of his death he was associated with the North American Cyanamid Ltd. where he began as field engineer in 1947.

John Clark Pickering, (Member 1914) retired mining engineer, died on Oct. 10, 1956, in Ft. Lauderdale, Fla., at the age of 73. A native of New York, Mr. Pickering spent many years in Latin America and also worked in Africa and the U. S., primarily engaged in the mining of zinc, lead, copper, silver, gold, and tin. He was associated with Cerro de Pasco Mining Co. in Peru from 1904-1907, first as a surveyor, later as chief engineer. He was general manager, Buena Tierra Mining Co. in Mexico, and from 1914 to 1917 he served the Eugene Meyer, Jr. & Co., consulting engineers of New York. After World War I, Mr. Pickering held executive posts in Mexico for the Exploration Co. Ltd., and finally became general manager of the Patino Mines & Enterprises Consolidated Inc. in Bolivia, remaining in this post from 1927 until his retirement in 1939. He was the author of numerous technical articles and also wrote two books, *Engineering Analysis of a Mining Share* and *Cost Keeping for Small Metal Mines.*

Oliver J. Egleston (Member 1919) died on August 23, 1956, of a cerebral hemorrhage. Born in 1918 in Wykoff, Minn., he was a graduate of the University of Minnesota School of Mines. A retired vice president and consulting engineer for U. S.

(Continued on page 377)

Coming Events

Mar. 21, AIME Utah Local Section. Speaker: W. Don Quigley, Consulting Geologist; subject: *Discussion of the Aneth and Associated Oil Discoveries in the Paradox Basin.* Newhouse Hotel, Salt Lake City.

Mar. 25-29, ASM, 10th Western Metal Exposition and Congress, Pan-Pacific Auditorium and Ambassador Hotel, Los Angeles.

Mar. 29-30, Conference for Engineering Administrators and Personnel Executives, Kellogg Center, Michigan State University, East Lansing, Mich.

Apr. 1-4, American Assn. of Petroleum Geologists, annual meeting, Kiel Auditorium, St. Louis.

Apr. 5, 6, AIME Pacific Southwest Mineral Industry Conference. Sponsored by Nevada Section, cosponsored by San Francisco and Southern California Sections. Reno.

Apr. 8-10, AIME, National Open Hearth Steel and Blast Furnace, Coke Oven, and Raw Materials Conferences, Penn-Sheraton Hotel, Pittsburgh.

Apr. 10, AIME Utah Local Section, AIME Student Section, University of Utah, dinner meeting. Speaker: A. B. Kinzel, AIME President-Elect; subject: *The New Elements.* Union Hall, University of Utah, Salt Lake City.

Apr. 11-13, AIME, Pacific Northwest Regional Conference, Multnomah Hotel, Portland, Ore.

Apr. 21-24, Second Annual Symposium on Rock Mechanics, Sponsored by Colorado School of Mines, Golden, Colo.

Apr. 22-24, CIM, annual meeting, Ottawa, Ont., Canada.

Apr. 24-25, Lead Industries Assn., annual meeting, Drake Hotel, Chicago.

Apr. 25-26, American Zinc Inst. Inc., 39th annual meeting, Drake Hotel, Chicago.

May 6-8, Institute on Lake Superior Geology, annual meeting, cosponsored by AIME Exploration Subsection, Upper Peninsula Local Section, Michigan Geological Survey, and Michigan Geological Society. Kellogg Center, Michigan State University, East Lansing, Mich.

May 13-16, Coal Convention and Exposition of the American Mining Congress, City Auditorium, Cleveland.

May 16, AIME Utah Local Section. Speaker: A. E. Millar, General Manager, The Anaconda Co., Yerington Mines, Weed Heights, Nev.; subject: *The Yerington Story.* Newhouse Hotel, Salt Lake City.

May 23-24, Lake Superior Mines Safety Council, 33rd annual conference, Hotel Duluth, Duluth.

May 24-25, AIME Central Appalachian Section, spring meeting, Maple Shade Inn, Pulaski, Va.

June 16-21, ASTM, annual meeting, Chalfonte-Haddon Hall Hotel, Atlantic City, N. J.

Sept. 8-Oct. 9, Commonwealth Mining and Metallurgical Congress, British Columbia to Nova Scotia, Canada.

Sept. 9-12, American Mining Congress, annual convention, Utah and Newhouse Hotels, Salt Lake City.

Sept. 18-21, International Mineral Dressing Congress, Royal Inst. of Technology, Stockholm, Sweden.

Oct. 6-9, AIME, Petroleum Branch, Dallas.

Oct. 9-11, ASME-AIME Coal Div., Joint Solid Fuels Conference, Chateau Frontenac, Quebec.

Oct. 15-18, Southeastern Mining Branch Conference, Hillsboro Hotel, Tampa, Fla.

Oct. 30-Nov. 1, AIME, Rocky Moutain Minerals Conference, Denver.

Nov. 4-6, AIME, IMD Fall Meeting, Morrison Hotel, Chicago.

Nov. 11-14, Society of Exploration Geophysicists, 27th Annual Meeting, Statler-Hilton Hotel, Dallas.

Dec. 1-6, ASME, Annual Meeting, Hotel Statler, New York.

Dec. 4-6, AIME, Electric Furnace Steel Conference, Penn-Sheraton Hotel, Pittsburgh.

Feb. 16-20, 1958, AIME Annual Meeting, Hotel Statler, New York.

BOOKS

(Continued from page 298)

Geophysical Case Histories, Vol. II, *The Society of Exploration Geophysicists,* P.O. Box 1536, Tulsa, Okla., 676 pp., $7.00, 1956.—This is a collection of 53 case histories categorized as: general and historical, salt domes, anticlines, reefs, stratigraphic traps, mines, and new uses. Seismic records and maps accompany many of the papers.

Some Uranium Occurrences in West Texas, by D. H. Eargle, *Bureau of Economic Geology,* University Station, Box 8022, Austin 12, Texas, 21 pp., 35¢, 1956.—Prepared in cooperation with USGS, this pamphlet (Report of Investigations—No. 27) discusses the location, discovery, geology, and prospects of the uranium sources of the west Texas area.

Sampling Limestone and Dolomite Deposits for Trace and Minor Elements, by J. E. Lamar and K. B. Thomson, *Illinois State Geological Survey,* Urbana, Ill., 18 pp., 2¢ postage, 1956.—This circular, No. 221, gives the results of an investigation into the problems of sampling procedure raised by the trace and minor elements in limestone and dolomite, especially those used for agricultural limestone.

Proceedings of Mining Research Conference, Technical Series No. 92, *Missouri School of Mines,* Rolla, Mo., 42 pp., free, 1956.—This booklet presents the proceedings of a conference held in October 1955, at the University of Missouri and co-sponsored by the Bureau of Mines, and the School of Mines and Metallurgy, University of Missouri. Among the subjects included are geomechanics, statistical analysis in computing reserves and grade of ore, and the future outlook of mining technology.

Ferruginous Bauxite Deposits in the Salem Hills, Marion County, Oregon, by R. E. Corcoran and F. W. Libbey, *Dept. of Geology and Mineral Industries,* 1069 State Office Bldg., Portland 1, Ore., 50 pp., $1.25, 1956.—Bulletin No. 46 of the State of Oregon publications, this study presents a chemical and spectrographical analysis of the parent basalt, clay, and bauxite of the area, and the type, shape, size, location, and geology of the orebodies are described.

Bibliography of Mining Theses at U. S. Institutions, compiled by H. L. Hartman, Quarterly of the Colorado School of Mines, Vol. 51, No. 2, *Colorado School of Mines,* $1.00, 1956.—This bulletin lists the theses prepared at 23 of the 28 U. S. schools offering graduate work in mining engineering. Theses are arranged alphabetically, according to subject, school of origin, and author, in three sections.

Necrology

Date Elected	Name	Date of Death
1941	Stanley L. Arnot	Unknown
1948	Frank J. Cole	Dec. 30, 1956
1954	Hale O. Davis	Unknown
1954	Max W. Dessau	Dec. 12, 1956
1936	Harold Stewart Elford	Unknown
1907	S. C. Faneuf Legion of Honor	Jan. 2, 1956
1950	J. Preston Irwin	Jan. 1, 1957
1930	Walter H. Jacobson	Dec. 19, 1956
1953	Marvin L. Kay	Dec. 7, 1956
1953	Fred C. Krebs, Jr.	Unknown
1942	A. M. Rippel	Dec. 12, 1956
1955	Eugene G. Saari	Unknown
1947	J. E. Settle	Sept. 14, 1955
1928	Edward W. Spottswood	1951
1919	Albert E. White	Dec. 18, 1956
1944	J. Lloyd White	Oct. 26, 1956

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Smelting, Refining and Mining Co., he worked his way up through the ranks, starting in 1901 as an engineer and becoming chief engineer, then general manager of western operations.

Walter M. Briggs (Member 1929) died recently. He was born in St. Louis in 1871. A graduate of Harvard University, he became secretary-treasurer of Tennessee Copper Co. and the Great Northern Development Co. and in 1917, president of Regal Mines of Alaska in California.

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The Institute desires to extend its privileges to every person to whom it can be of service, but does not desire as members persons who are unqualified. Institute members are urged to review this list as soon as possible and immediately to inform the Secretary's office if names of people are found who are known to be unqualified for AIME membership.

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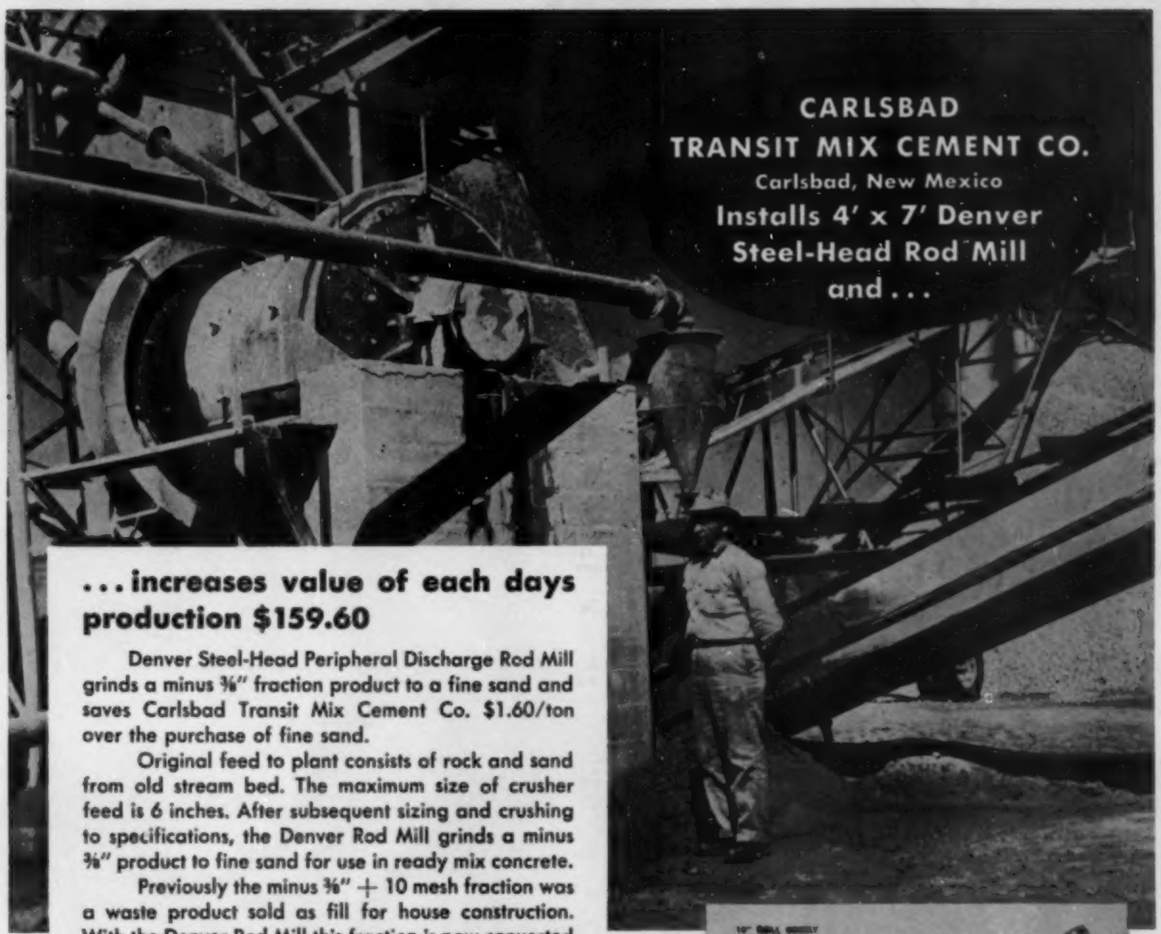

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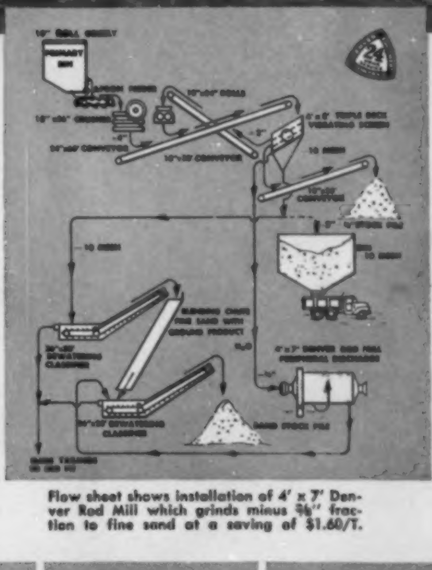

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